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LEADERSHIP IN SCIENTIFIC RESEARCH

THE series of papers on research and its organisation by Dr. Ellice McDonald, director of the Biochemical Research Foundation of the Franklin Institute, originally published in the *Journal* of the Institute, have recently been re-issued under that general title, together with an earlier paper on a bonus system in a research organisation, and two more recent papers on biochemical and medical research, one by Dr. McDonald and one by Dr. W. A. Mosher*. Covering the choice of research projects, co-operation in research, the direction of research and the choice of workers in research, these papers make a contribution to the literature on the administration and organisation of research, which is the more useful for being drawn from the author's personal experience and quite independent of other current writing in this field.

In this brochure Dr. McDonald discusses first the changing face of research, and, after commenting that the influence of the research worker on the community is indirect rather than direct, emphasizes that the changes in recent years are due, first, to the annihilation of distance, then to the increased scale of operations and, third, to the increased use of power. The improvement in rapidity and ease of communication due to the first factor has accelerated the progress of research to an extraordinary degree, while the increased scale of operations has not only encouraged the extension of team-work and of large co-ordinated groups, but has also had its effect on the exchange of information. The increased use of power has had its effect chiefly in the large numbers of instruments of precision which have been devised to extend the research worker's range of observation.

Dr. McDonald argues that the influence of these changes has been most marked in the field of development rather than in that of discovery and research, and he questions whether a planned and completely co-ordinated research programme on a national scale would offer any advantage over independent research activity. Discoveries are made by individuals—men and women—and if the free spirit of research is hampered, vision is impaired. A planned research tends to concentration in much detail in a few directions, and accordingly, he argues, the chance of hitting the correct solution is less.

The chief stress, however, is laid by Dr. McDonald on the creative aspect of research and the need for a sympathetic understanding of the research instinct and for untrammelled development of its creative genius. This, he urges, is a main factor to be taken into account in choosing research projects. The proper choice of research topics, he rightly insists, is the vital factor determining success in research; he defines research projects as experiments directed by the disciplined imagination of a group of individuals of varied mental outlook and diverse training, who are able to transcend the results obtained by the

* Research and its Organization. By Dr. Ellice McDonald. Pp. 96. (Newark, Del.: Biochemical Research Foundation, 1950.)

isolated scientific worker, save for the exceptional genius. Commonplace qualities, well trained, well proportioned and consistently well displayed, will in organised groups, he maintains, give consistently better success than any individual effort.

The dangers and limitations in the planning and organisation of research are clearly well understood by Dr. McDonald; in this connexion his thought seems to run on similar lines to that of Dr. E. F. Caldin, in his recent book, "The Power and Limits of Science". He writes wisely on the postulates to be considered in selecting a research project—and no less in abandoning it—and here again the effect on the staff concerned is uppermost in his mind. While recognizing that many important discoveries have been made by accident, he points out that by far the greater number have been made by design, and to his mind the vital task appears to be so to present accumulated and recorded experience to the next generation of research workers that they live in an atmosphere of intellectual stimulation and are inspired to imaginative activity.

The very wealth of that experience, however, enforces the need for co-operation in research as in other fields. Coupled with the vast increase in the complexity, range and expensiveness of the tools available for research, it has made organisation imperative if the size of operations is to match the new opportunities. Dr. McDonald recognizes that we are only now discovering the art of working together, and he defines the art of good management as the creation of an organisation which will develop to its highest point the initiative of individuals, consistent with an orderly progression and cohesiveness of purpose. The purpose of management and of the collective intelligence, experience and imagination (which imply direction to a given scientific task in research) is likewise to expand the power of each individual worker to be useful; and in this connexion he has in mind particularly the facilitation of co-operation and the interchange of experience between different specialists and across the frontiers of different disciplines. Many gaps in the uneven front of research to-day, he reminds us, are represented by unexplored fields which lie between the activities of two or more branches of science. These gaps can only be filled in by the interchange of ideas from day to day and over a long period of time, because it is difficult for men of science in different fields to learn the *patois* which each speaks. A large research organisation is one means by which that difficulty can be overcome, and when due regard is had to the inherent weaknesses of such an organisation to which Dr. McDonald directs attention, the risk of it cramping originality of thought or repressing the flair for discovery is small.

Under present conditions, a certain amount of organisation in research is inevitable. The essential task is how to minimize its weaknesses and drawbacks; and much in the first place depends on the manner in which the direction of research is exercised, and especially on the director of research himself. Dr. McDonald's ideas on this point are clear and incisive. He has no delusions or exaggerated ideas on the part the director or research manager has to play. It is an administrative task calling for someone who, while sufficient of a man of science to understand the outlook of the research worker, is prepared to set on one side any personal interest in research and to take upon his shoulders the bother of the details inherent in an organisation, so that the research workers themselves may be relieved and free to concentrate their energy on the prosecution of their investigations.

Such a task calls for all the qualities of leadership in the full sense of its meaning—ability to understand and to handle men, sensitiveness to the atmosphere in which research is most effective and creative, and unflagging zeal to secure and maintain the appropriate atmosphere as well as the mechanical and intellectual tools required. A director of research to-day is required, too, to take account of the outlook and thought of scientific workers of diverse character and training if he is to weld them into a successful team. The planning of resources in men and women, as well as in material equipment, must figure in successful strategy.

Much here will, as Dr. McDonald points out, depend on the wise and careful choice of workers, though besides choosing the best it may also be necessary to get rid of those who fall short of the standard. No list of qualities—judgment, common sense, modesty, originality, precision, and an unquenchable curiosity are all indicated by Dr. McDonald—can replace the capacity to estimate men and their ability, though experience has a valuable part to play. In the paper in which he discusses the selection of research workers and the qualities they should possess, Dr. McDonald is not completely happy, and in one passage he lapses into a gibe at the amateur. He admits the difficulty of recognizing genius; but in claiming that the lone research worker has a span of only three years in which his ideas are prolific, he seems unduly pessimistic. He suggests that in an appropriate organisation the stimulating contact with other men of science and other fields of work can prolong the creative life of the individual. If, as Prof. C. J. Renier wrote in his recent book, "imagination is nothing but the mobilization of the contents of our memory", there may be something in this view. Much will still depend, however, on personal qualities or characteristics if the effective group co-operation and stimulus are to be secured. With the exceptional worker—and it is the man or woman with outstanding ability in research that Dr. McDonald appears to be considering—this cannot be taken for granted. He recognizes, indeed, that some seem to find impossible the give and take which is required in group research, and there are others who will require educating in this respect before they learn that they, as well as the group, profit from the interchange of ideas and from contact with other branches of science. Some few, indeed, will have no place in the modern scheme of research.

In these highly suggestive papers, Dr. McDonald has both emphasized some of the most important factors upon which success in research depends and has also indicated some of the directions in which

still further knowledge is required. We are still far from understanding fully the conditions for the stimulation of creative work in scientific research, particularly that concerned with several disciplines or branches of science.

THE SEARCH FOR MAN'S ANCESTRY

Finding the Missing Link

By Dr. R. Broom. Pp. vi + 104. (London: Watts and Co., Ltd., 1950.) 6s. net.

DR. ROBERT BROOM's wonderful discoveries of the remains of primates in the South African cave-deposits during the past fifteen years, following his most valuable finds of fossil Mammalia and Reptilia, have commanded the admiration and gratitude of the scientific world. Now, for the instruction of the non-specialist reader, he provides an entertaining account, in racy and often extravagant language, of his efforts to discover the connecting link (as Huxley and Darwin termed it) between ape and man. Modesty doubtless caused him to refrain from entitling his little book "Finding some Missing Links".

The volume opens with a review of the history of discoveries of ancient or supposedly ancient human remains, the provenance of which in some cases is doubtful. Next, the story of the remarkable finds in China and Java, brought up to date, serves as a fitting introduction to his fascinating description of the treasures he has himself unearthed at the Sterkfontein, Kromdraai and Swartkrans caves, and of other discoveries at Taungs and Makapan, until so recently as 1949. The chief value of the book lies in this first-hand narration of his vigorous, persistent and successful labours. In the concluding chapters he discusses the affinities of the ape-men (as he terms them: grouped as the Australopithecines, after *Australopithecus africanus* Dart from Taungs) that he and Prof. R. A. Dart have found, and he includes some animadversions on man's evolution and his place among the primates.

Although the author has been publishing his scientific work for more than half a century, he retains much of the energy, as well as some of the impatience, of youth. Many of his remarks about his contemporaries in the fields of anatomy, archæology and geology are deplorable: such can be ignored except in those cases where the layman is likely to be misled as to the facts. Contemptuous of the cautious attitude of many leading authorities, he scorns the "suspense account". We must not forget, though, that the story of man's ancestry has such a universal appeal that more than ordinary caution is necessary when we come to present evidence for missing links. Dr. Broom will not have forgotten that the path of progress in the study of primitive man is strewn with discarded but monitory remains like those of Galley Hill man, Ipswich man and Oldoway man, to mention only a few; that *Ecanthropus*, 'The First Englishman', now appears unhappily named; and that *Pithecanthropus*, the 'missing link' of the headlines of sixty years ago, has been deposed from his crucial position in the geological time-scale and deprived of any anatomical claim to be the ancestor of modern man. Small wonder if the pendulum should occasionally swing too far the other way. Some such recollections as these will be in the mind of the critical reader who peruses this small volume.

Although there is some difference of opinion about the affinities of the Australopithecines, Dr. Broom's conviction that they are allied to man rather than to the apes is shared by certain other authorities (see *Nature*, November 4, p. 758). The names he may attach to his ape-men (like *Paranthropus* and *Plesianthropus*) matter less at the moment than his conjectures about their geological age and his observations on the finds elsewhere of what were claimed to be the remains of very early man. In support of his belief in the great antiquity of the ape-men, for example, he asserts that "We know that man of some sort lived in Upper Pliocene", and then refers to the records of *Homo sapiens* from ancient deposits in Kenya. Here he is on unsafe ground, for his statement that Kanjera man belongs to the "fairly early Pleistocene" is in conflict with the evidence. Even if the fragments of the Kanjera skulls were indigenous to the deposit on or in which they were found, the fauna contained in the oldest beds in the district indicated an age no greater than late Middle Pleistocene, and the stratigraphical relationships suggested that the skull-bearing deposit belonged to a younger series—possibly much younger[1]. Other statements made in connexion with the Kanam and Kanjera finds are not in accord with the facts. After declaring that he has looked very carefully into the history of these East African discoveries, he expresses his whole-hearted belief in them and his conviction that the provenance of the remains is not in doubt. In view of the weight that might be attached to his opinion on this matter, we would remark that his investigations do not appear to have been sufficiently thorough to enable him to realize that the "critic" (whose report[2] is quoted as an example of pre-existent bias) had to insist, in the face of opposition, that systematic excavations (unfortunately not undertaken at the time of the discovery) should be carried out at the supposed site of the Kanam mandible in the hope that further discoveries would relieve him of the necessity of placing it in a "suspense account". Moreover, apart from the difficulty that arose from the failure to mark the site so that it could be identified, the geological features of the deposits thereabouts were such that it was not at all certain that the parent-bed of the mandible (a decayed and abraded specimen obtained at the surface by a native boy) could be determined positively. In fact, the fragment could have been younger than, or of the same age as, or older than, the bed from the surface layer of which it came.

These East African remains provide, then, no evidence in support of the view that the Australopithecines are pre-Pleistocene. Nor does the fact that the latter are accompanied by genera of mammals now extinct in South Africa necessarily prove great antiquity, although further palæontological work may in time assist in dating the beds. There remains the evidence of superposition and petrology (and, dependent on the latter, that of past climatic and physiographical changes). It would have been interesting to know what steps Dr. Broom has taken to investigate the geology of the succession of and in the various cave-deposits, and why he accepted the surprising statement about Sterkfontein that "there was no stratigraphy whatever at the

place where I was working". Meanwhile, it is satisfactory to learn from other sources that the Australopithecine breccia in the Makapan area certainly antedates deposits containing the South African hand-axe industry of Middle Pleistocene age. The existence of still older, pebble-tool, etc., industries is well known; but the relationship that these, assigned to the Lower Pleistocene, bear to the bone-breccias has not yet been established. Since no implements have been found in association with the Australopithecines, it is not unreasonable to infer that these primates were too primitive to have been tool-makers, and therefore that they lived either in very early Pleistocene or in Pliocene times; but such deductions go no farther than inference. If the Australopithecines were ancestral to modern man (that is, missing links *sensu stricto*) and belonged to the early Pleistocene, and if the men who made the hand-axes were of *sapiens*-type (as the occurrence of the Swanscombe skull suggests), we are faced by a picture of almost incredibly rapid evolution. If, however, the Australopithecines all date from the Pliocene, as some authorities are inclined to think, our credulity is less severely strained; but we still cannot ignore the possibility that they are links in the anatomical sense only, that is, specialized or aberrant types like *Sinanthropus*, *Eoanthropus*, or Neanderthal man, rather than 'geological' links in the direct chain to sapient man. If they are all Pliocene and ancestral, we are left with an unbridged gap from Pliocene to late Middle Pleistocene, during which much could have happened. Dr. Broom has abandoned his earlier view that they were all Pleistocene, and now offers tentatively the succession: Taungs deposits ("say 2,000,000 years old"), Sterkfontein breccia ("say 1,200,000 years"), both supposedly Pliocene, and Kromdraai cave-deposits ("not improbably 200,000 or 300,000 years later than the Sterkfontein"), of Lower Pleistocene age, which would cover part of the gap but would raise again the problem of rapid evolution. Incidentally, it must be remembered that these figures and others in the book are no more than guesswork, and the preliminary word of caution about them may be overlooked or forgotten by the reader entranced by their repetition. We often tend to lose sight of the fact that measured chronology takes us back no more than 20,000 (or possibly 30,000) years; beyond that, all is speculation until the radioactive mineral time-scale comes into operation many million years earlier. Extrapolation based on rates of sedimentation, weathering and erosion, or on solar radiation—all controversial subjects—suggests that the Pleistocene may have begun about 500,000 or possibly 1,000,000 years ago, maybe more, maybe less.

The interesting conspectus with which the author concludes his volume, like the discussion in Prof. Le Gros Clark's admirable little guide on the primates recently published by the British (Natural History) Museum[3], makes us reflect on the present somewhat curious state of our knowledge of man's antiquity. For the time being, it is necessary to assume that, in different parts of the world, the boundary drawn between the Pliocene and the Pleistocene, as well as the stages, Upper, Middle and Lower, into which the Pleistocene has been divided (frequently on palæontological evidence), are severally contemporaneous. Then we find that, until the evolutionary burst of *Homo sapiens* occurred in late Pleistocene (Aurignacian) times, when he revealed himself as a highly developed tool-maker and artist not without a religious sense, the only reasonably authentic skeletal record of his existence is provided by the portion of a skull from Swanscombe, Kent, believed to be of late Middle Pleistocene age, that is, about 150,000 years older if we adopt a length of 600,000 years for the whole Period. Broadly, recent analysis in which palæontological evidence plays the most important part[4] indicates that the primitive Pekin *Sinanthropus* was apparently contemporaneous with him, and the Java "*Pithecanthropus*" but little more ancient (early Middle Pleistocene). Also approximately contemporaneous was the Piltdown *Eoanthropus*, recently relegated to the late Middle Pleistocene. Yet, implement-making was a well-developed art by Middle Pleistocene times, and tools of undisputed workmanship are found in earlier, sometimes much earlier, deposits (possibly Lower Pleistocene), although no skeletal human remains have been seen in association with them. And now, into one or more of the earlier chapters of the story, if not into the earliest, the Australopithecines must be introduced. Deprived of hoped-for assistance from the more dubious records referred to above, Swanscombe man, about whom we actually know very little, seems at present to carry an excessively heavy burden of responsibility in the matter of the antiquity of our sapient stock.

Discoveries outside South Africa thus afford no help at the moment in placing the Australopithecines in the geological time-scale, or in assessing their claim to be missing links. All the more urgent, therefore, is the need for intensive stratigraphical study of the deposits in and near the caves, to be aided in due course perhaps by modern geochemical methods for age-determinations, some born of recent isotope research. The important work of Prof. C. van Reit Lowe and his collaborators in South Africa encourages the hope that light will eventually be thrown on this outstanding problem in the borderland of geology and archæology.

P. G. H. Boswell

[1] See, for example, Kent, P. E., *Geol. Mag.*, **79**, 117 (1942).
[2] *Nature*, **135**, 371 (1935).
[3] See *Nature*, **166**, 216 (1950).
[4] Movius, Jun., H. L., Peabody Mus. Papers, Harvard Univ., 19, 3 (1944).

FUNDAMENTALS OF PLANT PATHOLOGY

Principles of Plant Infection

A Text-Book of General Plant Pathology for Biologists, Agriculturists, Foresters and Plant Breeders. By Prof. Ernst Gäumann. Authorized English edition by Prof. William B. Brierley. Pp. xvi + 543. (London: Crosby Lockwood and Son, Ltd., 1950.) 63*s*. net.

PROF. ERNST GAUMANN's "Pflanzliche Infektionslehre", which first appeared in 1946, is a notable contribution to plant pathological science inasmuch as it is the most substantial attempt so far made to bring the manifold details of research into one large picture. In the words of Prof. W. B. Brierley, who is responsible for the English edition, "it develops a consistent body of theory which correlates the facts into a logical and explanatory system". From time to time, it is true, the progress made in certain limited fields has been critically assessed, as in many admirable papers in the *Botanical Review*; but this book is something very much greater.

Not merely does it bring together and arrange an astonishing mass of data—for which alone workers in the subject will continue for many years to be deeply indebted to Prof. Gäumann—but also it is abundantly interwoven with original interpretations (always to be expected from this author) and unusual points of view. These also, as the editor points out, will prove "a mine of argument and controversy, and a source of endless discussion and questioning—which is what a book of this kind should be".

Of the translation, little need be said other than that it is very good indeed. The original drafts were made by a group of assistants, and the whole was afterwards revised and 'homogenized' by Prof. (and Mrs.) Brierley. This they have done so well that there is no evidence of its mosaic nature, and the text is singularly free of those rawnesses which tend to crop up in translated versions. There are occasional misprints, of which the outstanding one is "*sensu stricta*" (headings of all odd-numbered pages from p. 281 to p. 351).

Apart from a short account of disease control (which is almost in the nature of a postscript) the subject-matter is arranged in five long chapters, dealing with the mechanism of infection, transmission of disease, epidemiology, "disease proneness" of the host, physiological and morphological effects of disease, etc. The arrangement is logical, but it does, in fact, lead to a certain amount of repetition. Each topic is split up, again and again, so that the table of contents comes to wear rather a formidable aspect, and there are still further subdivisions in the text. One feels that the book is over-sectionalized—that distinctions are drawn which are not based on evidence of substance and that there are compartments which as yet are devoid of *bona fide* occupants.

This leads to the controversial points which Prof. Brierley mentions. They are here in abundance; in looking through the text, I have noted more than a hundred such places—places where I would query either the value of some data or the conclusion drawn, or the use of a word, or suchlike. The language is often teleological; but we are told in the preface that it is not to be so considered. One rather wonders then how it is to be considered. It is obviously impossible to set out these criticisms here, but they will occur to any student who reads carefully.

On the matter of terminology, with which this book is heavily loaded, there will no doubt be differences of opinion. Prof. Gäumann borrows freely from human medicine, and this is in conformity with his marked tendency to bring animal and plant pathology into the same pattern, in some cases rather incongruously. Other words are his own invention. Many of these, one feels, are superfluous, and their effect is often merely to lengthen the argument and nothing more. Prof. Gäumann's acute mind revels in fine distinctions, and he adopts or coins the appropriate words. It is almost with pleasure, therefore, that one finds that even he occasionally nods. Thus, in the first sentence of the book, the word "infection" is applied to the first of the five phases or stages of an infectious disease; on p. 36 it has come to cover the first two stages, and in the title of the book it is clearly intended to cover all five.

There remains the question of what kind of student will read his Gäumann with profit. The title-page speaks of it as a text-book for agriculturists, foresters (and others). I have no wish to disparage these people when I say that they would make little headway with it or get much of the specific information which would help them in their type of problem. The book is essentially for the plant pathological specialist, and for the more academically minded one at that. It has its uneven patches, and parts of it could be pruned away with advantage. Nevertheless, in its general scope and execution, it is a brilliant piece of work, and one which will undoubtedly stimulate and guide the plant pathological research of the future.

W. Brown

FUNDAMENTALS OF ADVANCED ORGANIC CHEMISTRY

Advanced Organic Chemistry

By Prof. G. W. Wheland. Second edition. Pp. xi+799. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1949) 64*s*. net.

At the outset of his postgraduate training in organic chemistry, many a serious student must feel a desire to retrace a portion of his previous path as an undergraduate in order to make a more determined effort to apprehend the underlying principles of the science which, owing to the congested curriculum of degree courses, he has necessarily considered mainly from the descriptive point of view. He would find the requirements of this undertaking provided in a most interesting and comprehensive manner by Prof. G. W. Wheland's thought-provoking book which now appears in its second edition. Rather than being an elaboration of facts, this volume attempts to place the simpler chemistry already learnt on a sound theoretical basis. The treatment is non-mathematical and "the primary guiding and unifying principle . . . is the structural theory in its broadest sense".

The first half of the book is devoted to a clear and critical review of the structural theory. The first chapters describe the forces binding atoms into molecules, the loose forces between molecules and the forces binding molecules into addition compounds, for example, the hydrogen bond. The spatial disposition of atoms in organic molecules is then discussed at length in five interesting chapters to form what must be one of the best summaries of stereochemistry in the English language. Discussions of steric strain and steric hindrance brought about by the interaction of atoms, and of the modification of 'classical' structures of molecules by resonance, form the subjects of the next two chapters. Excellent sections on molecular rearrangements (130 pages) and tautomerism (65 pages) then follow, and the book closes with a chapter on free radicals.

Throughout, the text is liberally supported with references to the original literature, including the most recent publications. In places, the emphasis on structural considerations has resulted in other physical evidence being overlooked. For example, in the account of the Walden inversion only one paragraph is devoted to a discussion of the mechanism of the phenomenon, the kinetic evidence for this being largely lost sight of. This, however, is but a minor criticism of an excellent book which can be unreservedly recommended to chemists for developing their critical outlook and increasing their real understanding of a fascinating branch of natural knowledge.

Principles of Organic Chemistry

By Prof. John Leo Abernethy. Pp. viii+317. (Philadelphia and London: W. B. Saunders Co., 1949.) 20*s*.

THIS is an elementary text-book designed to cover a first-year course of some ninety lectures on organic chemistry. On the whole, the treatment is orthodox, although the placing of emphasis is sometimes unusual, as a result, perhaps, of the author's "careful selection of topics, eliminating much of the material that . . . tends to make organic text-books encyclopedic sources of information, discouraging to the beginning student".

The book begins with a brief exposition of the Lewis electronic theory and then deals with aliphatic compounds with reference to their functional groups. Tautomerism is briefly mentioned; but in this connexion neither acetoacetic ester nor malonic ester is described, in spite of their theoretical interest and their practical utility. The structure of benzene is presented from the resonance point of view, and the problem of aromatic substitution explained on the principle of alternating polarity in a conjugated system. Aromatic compounds are dealt with in twenty pages and heterocyclic compounds in eight; but proteins, dyestuffs and oxidation-reduction reactions receive special treatment.

Nevertheless, the author achieves much in packing the bare, sometimes very bare, bones of organic chemistry into so small a compass. The early emphasis on nomenclature and formulation—so often a stumbling block to the beginner—and the useful problems collected at the end of each chapter are welcome features. The book is well produced and notably free from misprints; but on pp. 152–3 *tert*-pentyl occurs no fewer than seven times when *sec*-butyl is clearly intended.

Electronic Interpretations of Organic Chemistry

By Dr. A. Edward Remick. Second edition. Pp. vii+600. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1949.) 48*s*. net.

IN this second edition of his book, Prof. A. E. Remick has enhanced the value of the well-known first edition by a revision of the whole text and the addition of a new chapter entitled "Some Contributions from the Field of Stereochemistry". This has been achieved, while keeping the book within a reasonable size (and price), by severely abridging the historical introduction and omitting some appendixes.

The opening sections in general follow the historical development of electronic organic chemistry. Early theories of the reactivity of molecules are discussed, together with their translation into terms of electron shift and electron availability, by the application of the electronic theory of valency enunciated by Lewis. An account of the modern theory of this electron shift is then given and the theory shown to be firmly based by the presentation of supporting evidence; this occupies the remainder of the first half of the book. The principles are then applied to electron-sharing reactions involving heterolytic bond fission, aromatic nitration and sulphonation, the extensive work on the substitution reactions of alkyl halides, ester hydrolysis, elimination reactions, etc., and to electron-pairing reactions involving homolytic formation and fission of bonds. Finally, the bearing of the theory on some branches of electrochemistry is discussed.

This book provides one of the best surveys of the uses of the electronic theory in organic chemistry—a field of speculation in which different schools have a tendency to use their own terminology and not infrequently disagree on interpretation of results.

Physics Tells Why

An Explanation of some Common Physical Phenomena. By Overton Luhr. Pp. ix+387. (London: George Allen and Unwin, Ltd., 1947.) 16*s*. net.

IN this book Prof. O. Luhr, who unfortunately died before publication, set out to provide an interesting and a popular study for the layman without the use of the mathematics which must of necessity accompany a serious study of formal physics. His aim is to explain in a simple fashion many of the common physical phenomena in relation to everyday life, and it must be readily agreed that he has produced a very readable and interesting book covering many branches of physics.

With the aid of simple and original diagrams, the author discusses both natural and man-made physical phenomena in language that a young student and the layman can easily follow, and into the 359 pages he has crowded an amazing amount of information. A further interesting feature of this well-written book is the group of short questions and answers at the end; the keen reader is able to test how much knowledge he has assimilated.

Since the time when the book was first published in 1943, two new chapters have been included dealing with more recent developments such as radar, jet-propelled aircraft, atomic energy, etc., and these conform in style to the general character of the rest of the book.

The Honeybee

An Introduction to her Sense-Physiology and Behaviour. By C. G. Butler. Pp. viii+140+6 plates. (Oxford: Clarendon Press; London: Oxford University Press, 1949.) 10*s*. 6*d*. net.

DR. C. G. BUTLER has written a comprehensive survey of what is known of the senses and behaviour of the honey bee, especially the behaviour, about which much has been learned in recent years. The knowledge is hard to come by without the help of such a guide as this. A better understanding of the habits, abilities and limitations of the honey bee in the collection and utilization of nectar, pollen and water is of the first importance to the practical bee-keeper; but the story will be welcomed by all interested in the insect world, whether as naturalists, physiologists or biologists.

Any such study must be coloured somewhat by the predilections of the author, so naturally the best work is found in those fields in which the author and his colleagues have been active. Anyone will have trouble, in the present state of knowledge, in interpreting what is known of vision in insects; but I am unable to accept either that the bee sees grey at the red end of the spectrum or that it is materially short-sighted. Some figures will require reconsideration; compare, for example, the data on pollen loads given on pp. 79 and 131. One dare not look twice at the bee illustrated on the publishers' dust cover; but it would be wrong to cavil at a few details in a work which must have involved great labour, is generally well done, and should satisfy a wide demand.

E. B. WEDMORE

APE OR MAN?

By Dr. R. BROOM, F.R.S., and J. T. ROBINSON
Transvaal Museum, Pretoria

IN 1925, Prof. Dart announced the discovery of a new type of higher primate that seemed to be somewhat intermediate between ape and man. This was the skull of the Taungs child which he called *Australopithecus africanus*. For some years there was considerable dispute between those of us who regarded the little skull as that of a being closely allied to the ancestor of man, and those who considered it only a variety of ape, allied to the chimpanzee, which by parallelism had come to resemble man in many characters.

Since 1936 we have made a large number of new discoveries, and this group of higher primates is now known by many skulls and skeletal remains of adults of a considerable variety of forms which we think should be placed in different genera and species.

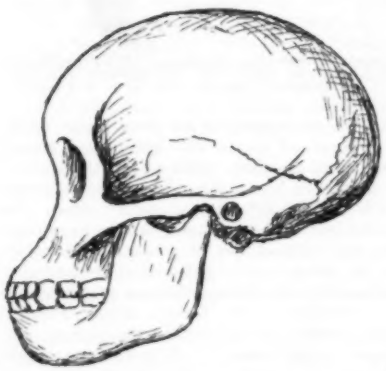

Fig. 1. Attempted restoration of seven-year-old male *Paranthropus crassidens* (½ natural size). The skull is almost complete, but the top is much crushed down on the base. The mandible is drawn from the jaw of another child. As restored the brain would be more than 700 c.c.

In the past two years we have discovered a number of nearly complete skulls which give us a new picture of the origin of man. When the only known skulls of our so-called 'ape-men' had brains of between 450 and 650 c.c., those who said they were only apes and had no close relationship to man seemed to have some case. But now that we have skulls with brains of 750, 800 and possibly 1,000 c.c., we seem to be dealing with beings that have some claim to be called human.

Recently we have found five skulls with fair-sized brains. One is a child skull with a brain of perhaps 600 c.c., and one that of a child with a brain of about 700 or 750 c.c. Then we have two nearly complete female skulls with brain cases which we estimate at about 800 or 850 c.c. Each skull lacks the occiput, but is otherwise nearly complete although somewhat crushed. It will take some time to reconstruct an uncrushed skull; but we seem very safe in considering that it had a brain of more than 800 c.c.

In structure the skulls are very interesting. The face is flat and broad. Above the eyes is a transverse supraorbital ridge; but it is more slender than in Pekin man, and a little like that of *Pithecanthropus*. There is practically no brow. The temporal muscles must have been relatively very large, and they passed up to the top of the skull as in male gorillas, and were separated by a bony sagittal crest rising about 12 mm. above the general surface of the skull. The ear region and the glenoid are almost typically human, and there is a large mastoid process and well-marked mastoid notch.

The palate and teeth are essentially human, and the incisors and canines would be accepted by most dentists as human teeth.

We have a perfect female mandible with all the teeth in perfect condition and a number of other jaws in fairly good condition. One striking feature is that all the jaws have some indication of a chin, and one has a typical human chin with a well-marked mental prominence. If we did not have the whole symphysis, which is very thick, and the molar teeth, which are certainly those of *Paranthropus*, we might suspect this jaw to be that of a *Homo*.

Then we have a very fine pelvis. It has a large, wide ilium, practically human and not at all ape-like, with an ischium that is not human and which also differs considerably from that of the Sterkfontein ape-man *Plesianthropus*.

When Dart described the Taungs ape-man the large majority of men of science in the northern hemisphere were of opinion that it was an anthropoid ape allied to the chimpanzee and gorilla. One went so far as to call it a "dwarf gorilla". But soon one or two came to the conclusion that, if an anthropoid ape, it is the one known that is nearest to man. But most anatomists apparently took little interest in the skull.

Fig. 2. Restoration of skull of female *Paranthropus crassidens* (½ natural size). The skull is satisfactorily known except the occiput, but is considerably crushed. The mandible is perfect, but is that of another individual. As restored the brain would be more than 800 c.c.

In 1936 the senior author started a search for an adult skull, as the child skull did not seem to be understood; and a fairly good skull of an adult allied to the Taungs child was found on August 17 at Sterkfontein. This was made the type of *Plesianthropus transvaalensis*. Two years later another type of skull was found at Kromdraai, and named *Paranthropus robustus*. Some anatomists in Britain and America assumed it as probable that the two adult skulls were merely adults of the Taungs species. Then in November 1948 another new type was discovered at Swartkrans and called *Paranthropus crassidens*. Even now there are, we believe, many who consider that all our types are at most only species of *Australopithecus*, and a few still hold that they are all anthropoid apes. A considerable number of men of science from America and Europe have visited South Africa to examine our specimens, and we think all who have taken this trouble have gone back convinced that at least we have the remains of beings that were much more human in structure than any known living or fossil apes.

Fig. 4. (*A*) Right pelvic bones of Swartkrans ape-man; (*B*) right pelvic bones of old female orang. Both one-third natural size, and similarly orientated in plane of ilium

Opinions still differ considerably. Some have argued that all our ape-men are true human beings. Some—a very few, we believe—consider they are anthropoid apes. Probably most prefer to wait, and call them ape-men.

Plesianthropus has a female with a brain of about 500 c.c., and this seems to us a brain scarcely large enough to entitle it to human status—though it may be in the human line.

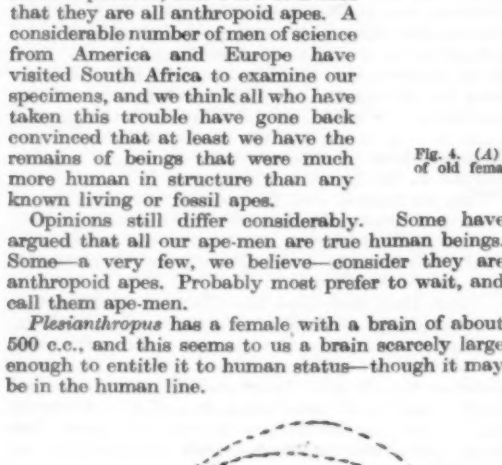

Fig. 3. Restoration of skull of male Swartkrans ape-man *Paranthropus crassidens* (½ natural size). Only lower jaw and face are known. As restored the brain would be about 1,000 c.c., and thus well within the human range

Paranthropus crassidens we now know fairly well. It has a brain of about 800–850 c.c. in the female, and perhaps more than 1,000 c.c. in the male. Even in the female it has a large bony sagittal crest. It has milk teeth differing so much from those of *Plesianthropus* and *Australopithecus* as to seem to confirm the correctness of placing it in a distinct genus. Its pelvis is also different in important details from those of both *Plesianthropus* and man.

The question now arises—must *Paranthropus crassidens*, with a brain well in the human range, be called an 'early man'? It is clearly an ape-man that has by a mutation developed a large brain—possibly in structure a human brain, and one might argue that it is an early type of man—perhaps the ancestor of man.

Again, the teeth seem to solve our problem. *Australopithecus* and *Plesianthropus* have remarkable milk pre-molar teeth. Man has exactly the same type. But *Paranthropus* has a more primitive type, so that it seems more probable that man (*Homo*) has evolved from a *Plesianthropus*-like type than from a *Paranthropus*.

Possibly we are correct in assuming that there lived in South Africa a million or perhaps two million years ago a family of higher primates, not closely related to the living anthropoids, but perhaps evolved from a very early anthropoid or even a pre-anthropoid by a different line, that this line early became bipedal and soon used the hands for tools and weapons, and that one branch of this family, about Upper Pliocene times, gave rise to man. There is no doubt the family varied greatly, and the safest conclusion to which we can at present come is that of the writer in *The Times* of July 28, who says: "It seems clear that the *Australopithecinæ* as revealed up to now were 'almost man', and their presence in the Transvaal a million years ago strongly reinforces the possibility that something which we should recognize as man was first evolved in Africa".

AUTOMATIC CONTROL SYSTEMS

By Prof. A. TUSTIN
University of Birmingham

AUTOMATIC control was the subject of a paper in Section G (Engineering) of the British Association at this year's meeting at Birmingham. It has since been the theme of a very well-attended conference at the University of Birmingham, and next year (July 16–21) it is to be the topic of a conference which is being arranged by the Department of Scientific and Industrial Research. The interest in the subject is world-wide, and is not confined to professional engineers.

This spate of interest and activity, like most spring tides, is due to a conjunction of causes. War-time developments such as automatic aircraft tracking, the guiding of flying-bombs, automatic gun-laying and many others led to a clearer understanding of what was possible, and suggested many industrial applications of the same principles.

New possibilities have been opened up by progress in developments of thermionic amplifiers, and the theory of amplifiers and filters, and by the appearance during recent years of a series of new forms of amplifier for larger powers. These include many varieties of rotary amplifier, such as the 'metadyne', the 'amplidyne', the 'rototrol' and the 'magnavolt'. There is also the magnetic amplifier—a development of the saturable reactor—and various controlled gas-discharge devices, such as the 'thyratron' and the grid-controlled rectifier.

A good deal of the present interest in automatic control arises from the fact that specialists in every branch of industry are asking whether some particular process can be done better under automatic control than under human control. They sometimes ask whether automatic control may make possible a precision and speed which no human operator could approach.

The recent developments in automatic control have been of interest to many scientific workers outside the field of engineering because of certain very striking analogies, and in a limited sense identity of principle, between the engineers' 'closed sequence controls' and a variety of phenomena in physiology, neurology, biology and economics which are somewhat analogous to 'situations of control', and which are characterized by the occurrence of oscillatory variations or instability.

The concept which has clarified the engineers' approach to control problems, and which is equally applicable to this wide range of phenomena in other fields, is that of a 'closed sequence of dependence'. In seeking to describe the behaviour of any system, one may characterize its state by the values of a number of quantities or variables. The equations describing the system state how the value of each variable is determined by one or more of the other variables. It is very illuminating to represent the 'scheme of dependence' diagrammatically as in Fig. 1. Here various interdependent quantities in a system are represented by the circles; and a line with an arrow, from B to C, for example, means that C is dependent on B, and alongside this arrow may be indicated (by the equation or an equivalent operational symbol) how the variation of the quantities are related. Such a diagram is simply a particular way of writing down the set of equations of the system. It makes visible

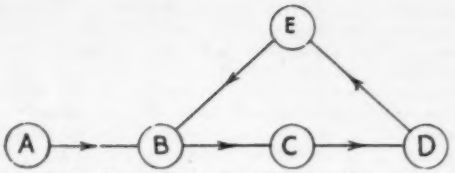

Fig. 1. Scheme of dependence with a closed sequence

a distinction which is of great importance in respect to the behaviour of such systems, namely, the existence or non-existence of any 'closed sequence of dependence', such as the sequence B–C–D–E–B in Fig. 1.

The significance of this distinction is that systems the scheme of dependence of which includes one or more closed sequences are liable to show various forms of 'self-excitation'. If the quantity B in Fig. 1, on increasing, causes, via the closed sequence, and subject to some time delay, an increase in B, then the behaviour of the system may, on certain conditions, be a sustained or cumulative increase in the value B. A kitten chasing its own tail is a good example of such a closed sequence system. We do not know what mathematical function would best describe the dependence of the activation of the kitten on the proximity and velocity of the tail; but the rate of gyration has been observed to rise to a considerable value, no doubt limited on account of the non-linearity of this dependence.

If, on the other hand, the response or 'feedback' via the closed sequence is not positive (or cumulative) but suppressive, self-excitation is still possible if this response is delayed in time; but in this case it is oscillatory, at such a frequency that the feedback is delayed in phase by 180°, and so is cumulative at that frequency.

Most control and regulating devices have 'schemes of dependence' of the same basic pattern as that given as Fig. 1, because they are 'error actuated' systems. For example, consider the auto-pilot of an aircraft. A device is provided that 'measures' the error ε of direction of flight from a required angle θ_i (relative to the axis of a gyro-compass). If the direction of flight is θ_o then $\varepsilon = \theta_i - \theta_o$. The error ε is caused to determine the angle of the rudder, which in turn determines the rate of turn of the aircraft, and so determines the variation of θ_o; and the direction of variation is, of course, made corrective. The basic 'scheme of dependence' is then as shown in Fig. 2.

The arrows from ε to θ_r and from θ_r to θ_o represent respectively the dependence of rudder angle on the error, and the dependence of direction of flight on rudder angle. Both these dependences involve time-lags, and the closed loop is suppressive. Thus the system is capable of self-oscillation if the response round the closed loop is sufficiently great at the

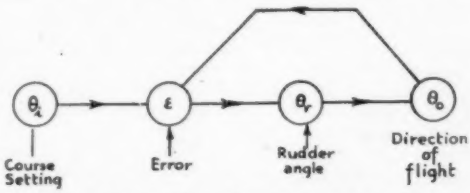

Fig. 2. Scheme of dependence for an automatic pilot

frequency at which the phase-lag is 180°. This sets a limit to the accuracy of control possible. Time-delays in the response of the 'control sequence' are the enemy of accurate control.

Present developments in automatic control largely centre around the search for means of amplifying power without undue time-delay. The thermionic amplifier is ideal for low-power stages, for its time-delays, in this context, are negligible. The high-power stages must, however, provide the required output, and in some applications, such as varying the 'draw' or tension in a steel-rolling mill, hundreds or even thousands of horse-power may be required. No means has yet been devised of obtaining continuous control of large powers which is instantly responsive to control signals of small power. These time-delays are usually due to storage of energy in the apparatus corresponding with each increase in output, and obviously such energies cannot in practice be built up instantly when some low-power input quantity changes, because such an instantaneous change would imply an infinite source of power. To a limited extent these supplementary energies may be supplied from the output or high-power end of the sequence, and this is the basis for the use of 'supplementary feedsback'; but the possibility of such further closed loops introducing new problems of stability will be obvious.

The occurrence of such closed sequences of dependence in many fields outside engineering would be expected. In the neuro-muscular systems of animals many examples occur. Derangement of such systems may produce characteristic oscillatory phenomena, such as tremors, or that periodic variation of breathing-rate known as Cheyne–Stokes respiration. In biology, the oscillations of competing populations may be described in this way. In economics, J. M. Keynes displayed the mechanism of the economic system as that of a closed-loop system, although he did not use this term. The principal closed sequence is: level of incomes – expectation of profit – rate of investment – level of incomes. There is also a sequence of higher periodicity, namely, income – spending – production of consumption goods – income. Economists now appear to accept the general implications of this closed-sequence situation, and the implementation of a full-employment policy largely depends on this recognition; but they appear to find difficulty in discovering, by field-studies or otherwise, the essential data relating to the time-functions involved in these dependences. If they could suggest possible forms for these time functions, electronic models could easily be contrived that would simulate the behaviour of an economic system for which they applied.

An advantage of recognizing the significance of closed sequences of dependence wherever they occur is that such recognition immediately makes available all the apparatus of analysis that has been built up around the engineer's problems, including the feedback amplifier. Particularly in the case in which the dependences, for some range of variation, are approximately linear, a great wealth of mathematical apparatus exists, which provides the answer to almost all questions likely to be of interest. Even when non-linear relations are involved, both useful methods of attack and a few useful general results are available, and in all cases, however complex, there are possibilities of semi-experimental investigation using electronic or other analogues. It is to be hoped that teachers of physics, mathematics and engineering will pay more attention to the concept of the closed sequence and its implications, not only because of its already very great importance in many fields of technology, but also because it provides an excellent example of a concept extending over a very wide range of phenomena, and provides a simple approach to many topics in applied mathematics, which is of pedagogic value.

There are two aspects of the study of closed-sequence systems which should be specially mentioned, because they are being actively investigated at the present time. The first is the application of automatic control in the chemical industry, and the control of chemical processes by measurement of physical quantities that indicate the state of material undergoing continuous processing, and regulation of temperature, flow, pressure and so on in accordance with these measurements. This field has its special difficulties because of the very long response-delays involved, and because of non-linearities in the response characteristics. A second field of present importance, in relation to defence as well as to industrial problems, is the behaviour of control which involves a human operator, that is, manual control. This situation involves a closed sequence via the dependence of the action of the operator on the quantities (meter readings or other indications) which he receives. As such responses, even of a highly trained operator, involve irreducible time-delays, the possible accuracy of manual control is limited. This situation arises, for example, in the control of high-speed aircraft from instruments, or in the laying of a telescope on a moving target. There is great interest in the processes by which, in the course of training, well-determined patterns of response are developed, and it may be expected that progress will emerge from such studies both in improvement of training methods and in the improvement of control characteristics.

BRITISH EMPIRE CANCER CAMPAIGN

ANNUAL REPORT FOR 1949

THE twenty-seventh annual report of the British Empire Cancer Campaign* is a substantial volume of 363 pages, giving an account of the biological, chemical, physical and clinical investigations supported by the funds of the Campaign (including administration and appeals, £212,000 were disposed of in 1949). No single reviewer could adequately deal with all four categories of research; moreover, compression and selection in this article, dictated by limitation of space, will leave many interesting topics unmentioned.

The rank growth of some lines of cancer investigation, particularly on the carcinogens and on tumour inhibitors, has rapidly led from discovery to the developmental phase, where a considerable proportion of the publications describe detailed methodical variations of conventional types of experiment. Interest has been stimulated by the introduction of modern physico-chemical theory in studying the relation of structure to activity of carcinogens and tumour inhibitors. The section of the report dealing

* British Empire Cancer Campaign. Twenty-seventh Annual Report covering the Year 1949. Edited by Sir Heneage Ogilvie. Pp. 363. (11 Grosvenor Crescent, London, W.1. 1950.)

with this branch of work is decidedly technical and will probably be beyond the scope of those readers whose physico-chemical education is a thing of the past. The explanation for the somewhat esoteric quality of this material is, of course, that the annual report of the Campaign is intended not only to give a general survey of the researches financed by its grants, but also to act as an internal bulletin for its own specialized investigators. It might perhaps be pointed out that physics and chemistry are well-developed sciences, whereas oncology has had barely half a century of painfully difficult progress in which to achieve half a dozen major discoveries.

In previous reviews of the annual reports (see *Nature*, **159**, 527 (1947); **161**, 385 (1948); **164**, 523 1949)) the writer has indicated the principal lines of investigation and development followed at the present time by the Campaign's centres of research, and has demonstrated that these lines are also pursued by cancer research workers internationally. The chief approaches are carcinogens and carcinogenesis, chemotherapy, the biochemistry of tumour and patient, and sex hormones in cancer; in the sphere of physics, the radioisotopes, the mechanism of the action of radiations and the development of radiotherapeutic technique; and thirdly, investigation of a clinical and pathological type.

The Campaign's clinical committee report is a lengthy document of fifty-seven pages; a "detailed statistical analysis of 242 cases of sarcoma of the soft tissues and of 132 cases of sarcoma of bone". It is from this kind of data that generalizations of extraordinary interest emerge, such as, for example, the relation of the patient's social class to cancer of the skin, of the penis, scrotum or cervix, and of the alimentary tract.

Radiological advances show a rapidly increasing use of radioisotopes, for example, bromine-82, phosphorus-32, sodium-24, iodine-131, zinc-65, sulphur-35, cobalt-60, potassium-40, radioiridium, radiotantalum and heavy nitrogen. Sodium-24 has been employed to irradiate cancers of the bladder by inserting into that organ a bag containing a solution of the radioactive salt, and also for measuring the effect of adrenal corticosteroids on the excretion of sodium from adrenalectomized rats; iodine-131 is used for the treatment of thyroid cancer and of lymphadenoid goitre; cobalt-60 is now considered as a substitute for radium, for it can be manufactured in the atomic pile; a study of the distribution of zinc-65 injected into the system has been undertaken on the grounds that the higher zinc content of some tumours might to some degree realize what has long been the aim of radiotherapists, namely, the exclusive irradiation of the tumour. This idea was, naturally, first applied to iodine-131 in the treatment of cancer of the thyroid.

Phosphorus-32 as phosphate has been given orally to patients suffering from polycythæmia and chronic myeloid leukæmia; the isotope can be detected in a limb opposite to the injection site in a few seconds, and in thirty minutes the uptake in the extracellular fluids is complete. By labelling antigens and antibodies with iodine-131, phosphorus-32 or sulphur-35 introduced into the protein molecule, experiments are being done on the fate of these substances in the body. Radiation from potassium-40 shows that "the average dose to human tissue due to β and α rays from their potassium content (i.e. naturally occurring K^{40} isotope) is estimated as approximately $3{\cdot}6 \times 10^{-5}$ r/day, that is, one third that received in the same time from cosmic radiation at sea level". In experiments on the synthesis of the protein component of nucleoproteins, glycine labelled with heavy nitrogen (nitrogen-15) was injected into irradiated rats, which were then sacrificed and the tissues assayed for nitrogen-15. Radioisotopes as therapeutic agents necessitate certain precautions; for example, if thyroidectomy has to be performed on a patient who has been treated with iodine-131, the instruments, gloves, dressings and towels used during the operation have to be carefully monitored and decontaminated.

The brilliant results achieved by antibiotics has naturally raised great hopes that the same successes will attend the search for chemotherapeutic compounds for cancer. This urgent pursuit shows no sign of slowing down. Certainly, the nitrogen mustards, the sex hormones (natural and artificial) and urethane have given dramatic, albeit temporary, clinical improvement. But unfortunately the mustards are violent poisons, and the sex hormones fail after a time because the tissues of the patient learn to adjust themselves to the new hormonic environment.

The chemotherapeutic potency of compounds is being investigated in the laboratory by reference to their nucleotoxic and radiomimetic activity and by the arrest of mitosis in chick fibroblasts in tissue culture, by their effect on the growth of broad bean root, by the capacity to inactivate hæmolytic complement and by their combination with proteins to give products with immunologically different characteristics. Among the latest anti-cancer drugs are folic acid analogues and other pterins; the ironical circumstance has arisen that anti-pterins are also being used for cancer chemotherapy (that is, analogues of the type of amino-pterins which compete with pterins in the tissue processes). The newer tumour inhibitory substances include some which have been synthetized, bearing in mind the structural formula of colchicine; others are 4-aminouracil and some compounds of the pyrimidine type; certain fractions of wool fat separated by crystallization from different solvents, chromatography and high-vacuum distillation; and, lastly, the alkaloids extracted from ragwort (*Senecio Jacobæa*) (which give an old-world flavour to this catalogue of anti-cancer drugs).

Apart from research and development in the field of radiology, carcinogenesis is probably the most popular theme of investigation. The nitrogen mustards have proved to be powerful carcinogens when injected into rats and mice. The search for an explanation of carcinogenic action is being carried on via a number of routes, for example, by an examination of the metabolic products from carcinogenic hydrocarbons given to rats and rabbits, and by a comparison between the order of biological activity of a chemical series of carcinogens and the order of their reactivity with perbenzoic acid. The idea that parallelisms of this kind (chemical, biochemical or physical) would suggest a mechanism of carcinogenesis underlies a great deal of the experimental and theoretical research in this important branch.

The conclusions drawn from Berenblum's highly suggestive and original work on the mechanism of tumour induction have been criticized by Gwynn and Salaman. Berenblum's method, very briefly, is to paint a solution of carcinogen (for example, methylcholanthrene) once only on the skin of a mouse. When at any time later (a few days up to six months)

the same area is painted with a co-carcinogen—croton oil—tumours arise after an interval, independent of the gap between methylcholanthrene painting and the beginning of painting with croton oil. Berenblum's interpretation is that painting once with carcinogen suffices irreversibly to mutate a few cells, the great majority of the cells painted returning to normal; when the skin is later treated with co-carcinogen, these mutated cells begin to grow as tumours. Carcinogenesis thus is a two-stage process, 'initiation' and 'development'. Gwynn and Salaman, using Glücksmann's technique of differential cell counts on small pieces of skin removed at biopsy, find that the whole area of skin reacts to treatment with croton oil by a rapid rise in the resting cell percentage. In other words, although after a single painting with methylcholanthrene the skin appears to return to normal, that normality depends on the technique used for its examination. However, this criticism does not disprove Berenblum's hypothesis; it suggests the need for support by subsidiary hypotheses, a fate which has overtaken other speculations in cancer research.

Industrial cancer is being attacked by a study of bladder cancer in the dyestuffs industry, where β-naphthylamine is known to be a dangerous intermediary in manufacture. It is to be hoped that the publicity given by industrial investigation and by experiments on laboratory animals will lead to this amine being generally prohibited in industry. Cancer of the hands and arms in engineering where lathe operators become splashed with cutting oils is being investigated by three groups of workers whose aim is to provide information for the Medical Research Council, which will then advise the oil companies on what types of oil can safely be incorporated in cutting oils.

Sir Ernest Kennaway's contribution to the report is, as usual, of special interest. He has investigated the relation of the hygienic measures laid down by religious practice to (1) the lower incidence of cancer of the cervix in Jewish women (lower, that is, than in non-Jewish women), and (2) the immunity of Jewish men to cancer of the penis.

Sir Ernest, in a study of the causes of the great increase in lung cancer in recent years, concludes that a case can be made out for an increasing pollution of the atmosphere and in the smoking habit. The conditions of temperature and oxygenation during tobacco smoking do not yield measurable amounts of benzpyrene, and he implies, although he does not state, that the carcinogenic agent might be the minute amount of arsenic in the tobacco which is applied in the insecticidal spraying of the growing crop.

Experiments with the same perspective, which could be described as factors in daily life as causes of cancer, have been carried out by Cornelia Hoch-Ligeti, who fed the fiery chillis (*Capsicum fruitescens* and *Capsicum annuum*) to rats. Twelve out of twenty-one rats showed some neoplastic changes in the liver (multiple cystic cholangiomata, solid adenomata) or adenocarcinomata of the bile duct. She states: "A decision has not yet been reached as to whether chilli should be considered a specific carcinogen or whether a deficiency in the diet, or a deficiency aggravated by chilli acting as a non-specific irritant, is the cause of the tumours. Both in the sequence of events which lead to their development and in certain histological features, these tumours bear a resemblance to the primary hepatic tumours which occur in man in certain parts of Asia and Africa."

Browning, after finding that two carcinogens applied to the tissues of an experimental animal in sub-threshold doses can reinforce each other, says: "The possible importance of such a finding has recently been emphasised in the matter of food adulterants. It is clearly not sufficient that dyes or other substances used in food should each be present in less than carcinogenic amount. The probability of more than one carcinogen being present in a food might constitute a danger as a result of such synergic effect."

The virus problem has attracted much attention in the past year, when Gye, Craigie and associates (at the Imperial Cancer Research Fund) announced that they had obtained evidence that mouse tumours were transmissible by a virus, since mouse sarcoma could be frozen and dried and yet would grow vigorously on grafting into healthy mice. The conclusions of Gye *et al.* depended entirely upon the premise that freezing and drying kills the cells of the tumour and liberates the virus. Investigators in four centres of the British Empire Cancer Campaign have now shown that such 'evidence' does little more than beg the question and that the drying technique is imperfect, and in one series of experiments, by Lasnitski, growth *in vitro* could still be obtained from the frozen-dried and reconstituted material.

OBITUARIES

Prof. M. L. Fernald

MERRITT LYNDON FERNALD, who died on September 22, had been for many years the leading student of the flora of eastern North America.

He was born at Orono, Maine, on October 5, 1873, and was appointed to the staff of the Gray Herbarium in 1891, taking his degree at Harvard in 1897. He was curator of the Herbarium during 1935–37, and succeeded B. L. Robinson as director in 1937, retiring at the end of June 1947. From 1915 until 1947 he was Fisher professor of natural history (botany). He was associate editor of *Rhodora*, the journal of the New England Botanical Club, when it was founded in 1899, and was editor-in-chief from 1929 until his death. It was in *Rhodora* that he published most of his detailed taxonomic studies.

Two of his earliest papers dealt with tropical species of *Pectis* and *Salvia*; but he soon turned to his real bent—the geography and taxonomy of the flora of eastern North America. Most happily he combined the two interests and made each serve the other. He was a natural taxonomic genius and a born field-worker; but his enthusiasm for collecting and minute critical analysis was controlled by the wider outlook of a true man of science. His exploration of Newfoundland, the Gaspé Peninsula and adjacent areas led to the publication of two papers which have become classics: "Persistence of Plants in Unglaciated Areas of Boreal America" (1925), and "Specific Segregations and Identities in some Floras of Eastern North America and the Old World" (1931). In later years he had concentrated on south-eastern Virginia, a region where northern and southern floras meet and overlap.

Fernald loved the most highly critical genera, such as *Antennaria*, *Solidago*, *Salix*, *Carex*, and the family Gramineæ. His most finished monographic work was

on the linear-leaved North American species of *Potamogeton*, Section *Axillares* (1932), and on *Draba* in temperate north-eastern America (1934). But the tremendous grip of his understanding and experience lay on almost every group occurring in his area, and woe betide the young student who rushed into print with ideas that did not work. At the same time, he held balanced, scholarly views on questions of nomenclature and orthography, such as well became him as an upholder of the conservative tradition of the Gray Herbarium. Fernald was a 'character', with strong convictions which made him a ready and voluminous writer, even by American standards. Fortunately, he was one of the really great systematists of our time. All his taxonomic knowledge is suitably gathered together in his great book, the eighth (centennial) edition of Gray's "Manual of Botany", which appeared not long before his death (forty-two years before, with Robinson, he had revised the seventh edition). He was honoured by many societies in the United States and northern Europe, and was honorary vice-president of the recent International Botanical Congress at Stockholm.

N. Y. Sandwith

We regret to announce the following deaths:

Dr. R. S. Clark, formerly director of the Scottish Home Department Marine Laboratory, Torry, Aberdeen, and naturalist on Shackleton's Antarctic Expedition of 1914–16, on September 29, aged sixty-eight.

Mr. C. E. C. Fischer, formerly of the Indian Forest Service and the Kew Herbarium, on October 19.

NEWS and VIEWS

Nobel Prize for Physics for 1950: Prof. C. F. Powell, F.R.S.

Prof. C. F. Powell, Melville Wills professor of physics in the University of Bristol since 1948, who has been awarded the Nobel Prize for Physics for 1950, was educated at Judd School, Tonbridge, and Sidney Sussex College, Cambridge. Following upon a first in physics in the Natural Science Tripos, he worked under C. T. R. Wilson on the condensation of steam. From Cambridge he went in 1928 to Bristol, in the first place as research assistant to Prof. Tyndall, where he was jointly or independently the author of papers on the mobility of gaseous ions. But it was afterwards as lecturer and reader that he initiated experiments to which he brought high technical skill and which have gained him wide recognition. In 1938, having built a Cockcroft generator to start work in nuclear physics, he tried an old method of observing the tracks of particles by shooting them into a photographic emulsion. Contrary to the opinion then held, he showed that under properly controlled conditions the method could be made to give quantitative data on nuclear processes and at an enhanced speed. Attempts to secure special emulsions were interrupted by the War; but when these were later available, the method forged ahead rapidly. In particular, Powell made a concentrated attack, from plates exposed at high mountain altitude, on the problem of the primary cosmic rays. In his laboratory, with its team of trained women scanners and collaborators like Occhialini and others, a stream of publications has issued. Of these, his discovery with Occhialini and Lattes of the heavy π-meson is perhaps one of the most important in its influence on present trends. But even more so is the instrument itself, a combination of a photographic emulsion and a microscope which he has fashioned and perfected into a tool of precision and the widest application in nuclear physics.

Nobel Prize for Literature for 1950: Earl Russell, O.M., F.R.S.

The award to Earl Russell of the Nobel Prize for Literature in 1950 is an event at once gratifying and revealing. Over the years, men of science, and the general public no less, have come to regard him as seer, savant and expounder; unique perhaps in his power to achieve high place in the grand debates of our age. But this is the Bertrand Russell of the Reith Lectures and kindred accomplishments, both here and overseas. The other—and maybe the real image rather than the virtual image—is the distinguished part-author of "Principia Mathematica", the Cambridge scholar at the height of his powers, driving, as it were, piles into the foundations of thought, to make the whole edifice not only more stable but also more beautiful. It is this æsthetic quality in his writings that makes him fit so appropriately with his fellow-prizemen in literature. The Nobel Foundation does not provide specifically for outstanding contributions in mathematics and philosophy; but if it did, the inclusion of Bertrand Russell's name in such a universe of discourse would scarcely escape anomaly, in view of his labours to reduce mathematics to logic. Possibly more by chance than by design, he comes to be in the right place. The theory of types and the clarification of paradox place their author well and truly among those who have created great literature, and in that category (but not excluding others) he is assured of universal felicitation upon his latest honour.

Tribute to Dr. J. A. Murray

The Royal Microscopical Society conferred an honorary fellowship on Dr. J. A. Murray in April 1949. In the June issue for 1950 of the *Journal of the Royal Microscopical Society*, a foreword by the president, Dr. R. J. Ludford, pays tribute to his friend and former teacher who, as the second director of the Imperial Cancer Research Fund, guided the activities of that organization through an early critical period. The contents of the *Journal* consist of seven papers by former colleagues of Dr. Murray who are, or were at one time, members of the staff of the Imperial Cancer Research Fund. The very high standard of these papers, and in particular the beautiful illustrations that accompany them, is an appropriate tribute to one who has done so much for the science of microscopy. It is not the purpose of this note to attempt to summarize the several papers; but the two papers by Ludford and Smiles seem to call for special comment, as they illustrate in the most striking and convincing way the relative merits of ultra-violet and of phase-contrast microscopy. Both techniques are superbly illustrated and justify in a remarkable way the well-tried techniques of fixation and staining for revealing minute cell structures.

Kelvin Medal Award: Prof. T. von Kármán, For.Mem.R.S.

THE Kelvin Medal Award Committee, consisting of the presidents of the Institutions of Civil Engineers, Mechanical Engineers, Electrical Engineers, Naval Architects, Mining and Metallurgy, Mining Engineers, Engineers and Shipbuilders in Scotland, and the Iron and Steel Institute, has awarded the Kelvin Gold Medal for 1950 to Prof. Theodore von Kármán, of the California Institute of Technology, in recognition of the eminent services he has rendered to engineering science in those branches of engineering with which Lord Kelvin was especially identified, and to commemorate which this Medal was instituted. The Kelvin Gold Medal is awarded triennially, the last award being to Sir Frank Whittle in 1947. Prof. von Kármán is an authority on the mathematical theory of hydrodynamics and aerodynamics and its applications, and was elected a foreign member of the Royal Society in 1946 (see *Nature*, **157**, 688; 1946).

University College, Ibadan: Endowment Fund

THE Nigerian Cocoa Marketing Board has contributed £1,000,000 to help endow the Department of Agriculture at University College, Ibadan. The Board is to establish a trust to administer the fund and will also set aside £50,000 of the grant for initial expenditure on agricultural buildings and equipment. This munificent gift follows a number of similar endowments made by the Board within the past three years: £225,000 in 1949 to provide in perpetuity a total of fifteen free places for the sons and daughters of cocoa farmers at University College, Ibadan; £25,000 in 1948 to finance a survey of the economy of the cocoa-producing areas of Nigeria and, in the same year, subsidies to farmers in compensation for the cutting out of diseased trees amounting to £150,000; a £310,000 grant in 1947 towards the endowment of the West African Cocoa Research Institute. During the course of the next few years the Board will also have helped to finance the building of new roads and to improve existing ones to the extent of £500,000. The Board has now given nearly £3,000,000, since its formation in 1947, for the benefit of Nigerian cocoa interests. Other costs for buildings and equipment at University College, Ibadan, are being met with a grant of £1,500,000 by the United Kingdom Government. Current expenses for a period of five years have been guaranteed by an annual grant of £100,000 from the Nigerian Government, which is also making an initial grant of £250,000 to the College Endowment Fund.

Cotton Research Station, Namulonge, Uganda

IN the presence of many distinguished guests, among whom were representatives of the Colonial Office, the Cotton Board, the Raw Cotton Commission and the East African High Commission, together with agricultural officials from the cotton-growing Colonies of the British Commonwealth, the Sudan and from French, Belgian and Portuguese territories in Africa, the new Cotton Research Station at Namulonge, Uganda, of the Empire Cotton Growing Corporation was officially opened by the Governor of Uganda, Sir John Hathorn Hall, on November 9. The Station is staffed by the Corporation, and the capital cost and running expenses are found by the Colonial Development and Welfare Fund, the Cotton Industry War Memorial Trust and the Raw Cotton Commission, besides the Governments of the British cotton-growing Colonies in Africa, the Sudan Government and the Corporation itself, assisted by a grant from the Cotton Board. The Station, sixteen miles from Kampala, comprises more than 2,200 acres of land, of which it is hoped that 1,500 acres will eventually be under cultivation. The main building consists of laboratories totalling 15,000 sq. ft. in floor area and split up into sections to house the various scientific departments. The work of the Station will not be confined to the Uganda crop, but will also cover basic problems affecting the other African territories. Its establishment has been preceded by nearly twenty years of important research in Trinidad into the life-history of the cotton plant, and by even longer periods of practical work at experiment stations in South Africa and elsewhere in the Commonwealth. At present, in addition to Uganda, the staff of the Corporation are stationed in the Sudan, Tanganyika, Nyasaland, Nigeria and the West Indies, where they work in close co-operation on cotton breeding and the many other problems which confront the grower.

Nigerian Broadcasting Service

MR. T. W. CHALMERS, controller of the Light Programme of the British Broadcasting Corporation, has been appointed head of the new Nigerian Broadcasting Service. He will have to build up a system that will cover 370,000 square miles, providing broadcasts in at least ten different languages to a population of 25 millions. He will have to encourage the formation of community receiving centres in remote villages, and the import and sale of cheap radio sets such as the so-called 'saucepan special' which has been well tried in Northern Rhodesia. There is at the moment only one wireless transmitting station in the Colony, 'Radio Nigeria', a low-power experimental unit situated in Lagos and serving some 1,800 listeners, who, however, can also receive the programmes of the B.B.C.'s Overseas Service. In addition, daily programmes are transmitted over a wired broadcasting system from local studios to ten towns in the Colony, where they can be heard on 9,300 loudspeakers. Only 0·2 per cent of the population can listen to broadcasting of any kind. The present scheme is designed to expand the transmission of programmes, both by radio and line. Two broadcasting engineers, Mr. L. W. Turner, of the B.B.C., and Mr. F. A. W. Byron, of the Crown Agents for the Colonies, carried out a technical survey last year under the auspices of the Colonial Office and the Nigerian Government. Six wireless stations will be built at a capital cost of about £350,000, to be shared by the Nigerian Government and the United Kingdom, the latter making a grant under the Colonial Development and Welfare Act. Work will begin at once on two short-wave stations at Lagos and at Kaduna in the north. These stations should be working within eighteen months, and another short-wave and the three medium-wave stations will follow later.

Royal Society of South Africa: New Fellows

THE following have been elected fellows of the Royal Society of South Africa: Dr. G. W. Bond, for investigations in geochemistry, the chemistry of ground-water, the treatment of water supplied for power production and corrosion problems arising therefrom; Dr. J. Day, for zoological research, more especially in the fields of marine biology and ecology; Prof. G. A. Elliott, for research into cardiology and rheumatoid arthritis, and for his administrative

work as professor of medicine in the University of the Witwatersrand; Dr. L. King, for work on geomorphology, surface geology and other geological subjects in New Zealand and in South Africa.

Fourth Congress of the International Scientific Film Association

THE Fourth Annual Congress and Festival of Scientific Films of the International Scientific Film Association was held in Florence during October 14–22. The following officers were elected for 1950–51: *President*, John Maddison (Great Britain); *Vice-Presidents*, Luc Haesaerts (Belgium) and Jan Korngold (Poland); *Honorary Secretary*, Jean Painlévé (France); *Honorary Treasurer*, Mario Ponzo (Italy). Among the most important decisions reached during the Congress were those dealing with the setting up in Brussels of the first International Reference Film Library of scientific films; the adoption of a standard system of recording, and interchanging internationally, information about scientific films; and the production by international effort of a film on meteorology, for which a first treatment has already been prepared. Valuable progress on the part of the Research Committee and the Medical Committee was reported. Great Britain was represented by a delegation of ten members, including representatives of the Scientific Film Association of Great Britain, the British Council and the Royal Photographic Society. Great Britain also contributed about thirty per cent of the total of some one hundred and twenty films on a wide variety of subjects which were shown. The technical excellence and the scientific qualities of all of the films, in comparison with those shown in previous years, have given proof of a considerable advance in the production of this type of film.

Conference on Evolution and Education

A CONFERENCE on "Evolution and Education", sponsored by eleven scientific and social organizations, will be held in the Chemistry Lecture Theatre, University College, London, during December 8–9. The following papers (some followed by discussion) will be read: "The Evolutionary Process" (Dr. Julian Huxley); "The Teaching of Evolution" (Miss M. L. Johnson, Miss E. L. Buckley, Mr. R. Weatherall); "School Broadcasting and Evolution" (Mr. Richard Palmer); "Evolution and Christian Belief" (Dr. W. H. Thorpe); "Modern Views on Evolution in the Light of Recent Advances in Embryology" (Dr. G. R. de Beer). Further information can be obtained from the British Social Biology Council, Tavistock House South, Tavistock Square, London, W.C.1.

Conference on Homes and the Family

THE British Committee of the International Union of Family Organizations, which comprises seventeen scientific and social institutions, is arranging a conference on "Homes and the Family" to be held on November 23 at the Caxton Hall, London. The first session will deal with "The Housing Needs of the Family", and will be held under the chairmanship of Prof. Winifred Cullis. Mrs. Graham-Bryce will take the chair at the second session, which will deal with "Housing and Health: the Medical and Moral Effects of the Problem on the Family". Further information can be obtained from the Honorary Secretary, British Committee of the I.U.F.O., c/o British Social Biology Council, Tavistock House South, Tavistock Square, London, W.C.1.

Scottish Postgraduate Agricultural Scholarships

THE Department of Agriculture for Scotland has awarded the following postgraduate agricultural scholarships, commencing this year and tenable as shown: *Husbandry*, A. O. Ballantyne (University of Edinburgh), H. G. Livingston and J. W. Stoddart (University of Reading); *Agricultural Economics*, G. F. B. Houston and S. G. Strachan (Agricultural Economics Research Institute, Oxford); *Statistics*, St. C. S. Taylor (University of Edinburgh). The Department has extended five current awards for a further year, as follows: *Husbandry*, A. G. Campbell (Massey Agricultural College, Palmerston North, New Zealand), C. D. Reekie (Cornell University), and Miss M. I. Ore (University of Edinburgh); *Agricultural Engineering*, G. T. Ward (King's College, Newcastle upon Tyne); *Agricultural Economics*, K. A. Ingersent (University of Minnesota).

Lenzites thermophila Falck

DR. W. H. WILKINS, of the Mycology Laboratory, Oxford, writes: "Mr. K. St. G. Cartwright, of the Forest Products Research Laboratory, Princes Risborough, has directed my attention to the name *Lenzites thermophila* Falck 75 in Dr. H. S. Burton's communication published in *Nature* of September 30, p. 570. In 1946 I received from the Forest Products Laboratory three cultures labelled respectively by that Laboratory, *L. thermophila* Falck 75, *L. thermophila* Falck 75A and *L. trabea* (Pers.) Fr. 108. In view of this I ignored the note by Cartwright (*Trans. Brit. Mycol. Soc.*, **16**, 304; 1931) and the confirmation by Mounce and Macrea (*Canad. J. Res.*, **14**, 215; 1936) that *L. thermophila* Falck was synonymous with *Lenzites trabea* (Pers.) Fr., which latter name has priority. I apologize to Dr. Burton for having misinformed him on this point."

Announcements

MR. JAMES WILKIE, secretary of the Carnegie United Kingdom Trust, has been elected president of the Library Association for 1951 in succession to H.R.H. the Duke of Edinburgh. The next annual conference of the Association will be held in Edinburgh during June 4–8, 1951.

THE Gulland Laboratory of the Scottish Seaweed Research Association at Inveresk Gate, Musselburgh, will be officially opened by the Right Hon. Hector McNeil on November 24.

THE first annual report of the Commonwealth Scientific and Industrial Research Organization, for the year ended June 30, 1949 (pp. 137; Canberra: Commonwealth Government Printer, 1949; 7*s*. 9*d*.), of which a multilithographed copy was tabled in Parliament by the Organization's Minister last year (see *Nature*, April 29, p. 677), has now been printed, and copies are available for distribution.

A COURSE of four lectures on ecology, arranged by the Association of Agriculture, will be held at the University of London Institute of Education, Malet Street, London, W.C.1, two lectures being given during each of the mornings of December 9 and 16, commencing at 10 a.m. The emphasis of the course will be on ecology in agriculture and in school teaching, and the speakers will be Sir James Scott-Watson, Mr. A. P. Weller (Oxford Education Committee), Dr. A. S. Thomas (Nature Conservancy) and Prof. J. E. Nichols (Aberystwyth). The fee for the course is 2*s*. Applications should be sent to the general secretary of the Association of Agriculture, 238–40 Abbey House, 2 Victoria Street, London, S.W.1.

A PLANT VIRUS THAT MULTIPLIES IN ITS INSECT VECTOR

By L. M. BLACK
Brooklyn Botanic Garden, N.Y.

EXPERIMENTAL evidence for the multiplication of two plant viruses in their insect vectors has already been published by Fukushi[1-3], Kunkel[4,5] and Black[6]. Bawden[7] has adversely criticized this evidence in his book on plant viruses and the diseases they cause. It is not the purpose of this article to discuss the criticism of these earlier experiments, but to record briefly the main features of experiments with a third plant virus which are believed to leave no doubt about its ability to multiply in both its plant hosts and insect vector. These experiments were begun at the Rockefeller Institute for Medical Research, and since 1946 have been continued at the Brooklyn Botanic Garden.

The clover club-leaf virus, *Aureogenus clavifolium* Black[6], was shown to pass through the egg of its insect vector. Virus-bearing female leafhoppers, *Agalliopsis novella* (Say), were caged on Grimm alfalfa plants, *Medicago sativa* L., which are immune to the virus. Thirty nymphs were removed from the alfalfa plants as they hatched from the eggs deposited in the plant by the insects. Great care was taken to ensure that the young insects had no opportunity of feeding on the plants in which the eggs had been laid.

Each nymph was placed on a crimson clover seedling, *Trifolium incarnatum* L., and transferred at weekly intervals to a fresh seedling until it died. The clover test plants, which are susceptible to club-leaf, were observed in the greenhouse along with an equal number of uninoculated controls. None of the controls became infected, but 68 of 642 of the test plants did. These 68 plants were infected by 24 of the 27 insects that survived more than two weeks. None of the 24 insects infected plants until at least three weeks had elapsed from the time of hatching.

On February 8, 1945, a virus-bearing female leafhopper weighing 1·7 mgm. was mated with a virus-free male and the pair caged on an alfalfa plant. The alfalfa plant was grown in soil that had been steamed to kill weed seeds. The female produced 42 nymphs, of which 21 were tested individually on a series of four crimson clover plants and then discarded. Fifteen of the 21 produced infections. Therefore, on the average, the virus in the original female had been diluted approximately 1 : 30 among her progeny. The 21 remaining progeny were each placed on an alfalfa seedling, and when they became adults, the females were mated to virus-free males. The virus has a long incubation period in crimson clover, and in each generation insects had to be mated before any infectivity data were obtained on their sibs. The pair that produced the greatest number of progeny was chosen to continue the main line of descent. This was done in order to have a basis for selection that was independent of virus concentration and, also, to secure the greatest dilution possible. Usually in each generation about thirty pairs of insects were mated.

The family with the greatest number of progeny was chosen for the main line of descent and four supplementary families with more progeny than others and close to the main line were held in reserve. (The use of the word 'family' is restricted in this communication to a pair of insects and their progeny.) These supplementary families were discarded as soon as it was known that virus was present in the main line of descent. Ordinarily, in each generation a sample of about fifteen progeny from each of these five families was tested individually on crimson clover to determine the fraction that was infective. With some exceptions, each of these insects was fed in succession on each of three plants for three weeks. Another sample of about ten nymphs from each of the same five families was distributed, one nymph to each of a number of alfalfa plants, to provide females for continuing the line.

The experiment has been continued for more than five years through twenty-one generations of insects grown only on immune alfalfa without loss of infectivity. As shown in the accompanying table, the dilution of the original virus, assuming no multiplication in the insects, exceeded $1 : 2{\cdot}8 \times 10^{26}$.

CALCULATED MINIMUM DILUTION OF CLOVER CLUB-LEAF VIRUS DURING PASSAGE THROUGH THE EGG OF ITS INSECT VECTOR FOR 21 GENERATIONS

Generation	No. of progeny	Infectivity test	Reciprocal of Dilution	
			Each generation	Total
1	42	15/21	30	30
2	101	6/15	40	12×10^2
3	35	3/15	7	84×10^3
4	54	9/15	32	$2{,}688 \times 10^3$
5	60	3/15	12	$32{,}256 \times 10^3$
6	89	9/15	53	$1{,}709{,}568 \times 10^3$
7	104	6/15	42	$71{,}801{,}856 \times 10^3$
8	106	15/20	80	$574{,}414{,}848 \times 10^3$
9	64	3/20	10	$574{,}414{,}848 \times 10^4$
10	173	5/11	79	$45{,}378{,}772{,}992 \times 10^4$
11	88	6/21	25	$11{,}344{,}693{,}248 \times 10^5$
12	31	2/11	6	$68{,}068{,}159{,}488 \times 10^5$
13	52	0/15	0 (1)*	$68{,}068{,}159{,}488 \times 10^5$
14	59	1/10	6	$408{,}408{,}956{,}928 \times 10^5$
15	129	1/5	26	$10{,}618{,}632{,}880{,}128 \times 10^5$
16	60	11/20	33	$350{,}414{,}885{,}044{,}224 \times 10^5$
17	114	2/15	15	$525{,}622{,}327{,}566{,}336 \times 10^5$
18	50	2/15	7	$3{,}679{,}356{,}292{,}964{,}352 \times 10^5$
19	107	1/10	11	$40{,}472{,}919{,}222{,}607{,}872 \times 10^5$
20	128	5/10	64	$2{,}590{,}266{,}830{,}246{,}903{,}808 \times 10^5$
21	105	1/10	11	$28{,}492{,}935{,}132{,}715{,}941{,}888 \times 10^5$ or $2{\cdot}8 \times 10^{26}$

*This was the only point where the absence of virus in the family with the largest number of progeny necessitated shifting the main line of descent to the family with the second largest number of progeny. It is an anomaly that the test of this latter family happened to be negative and that of the abandoned family (not shown) happened to be positive in this generation. In spite of the negative test at this point it is permissible to multiply the reciprocal of the dilution by 1 instead of 0 because the occurrence of infective descendants means that at least 1 of the progeny in this family was infected.

This dilution is a most conservative estimate, because it does not allow for systematic errors underestimating the dilution of the virus. For example, it does not allow for virus remaining in the mothers, for deaths among the progeny before they were counted, or for the fact that other data clearly show that the tests of the progeny did not reveal all those that were carrying virus. As an illustration, if the infective fractions as revealed by the tests were real, the families with the largest number of progeny in each generation should have been free of virus many more

times than they were. Also, several females from a family were sometimes saved and produced progeny that were tested. Usually, all produced infective progeny. A case in point is the main-line family in generation 19; only one of ten insects tested was infective (see table); but five sister insects which had been saved for progeny produced infective offspring.

These experiments were controlled in several ways. The clover plants on which samples of insects from the main line were tested were matched in each generation with at least as many crimson clover control plants on which either no insects or virus-free insects had fed. None of these plants became diseased. Since none of the pots in which the caged alfalfa plants were grown ever produced weeds, the alfalfa was the only source of food for the insects. After these plants had been freed of leafhoppers, they were tested for the virus by means of insects from one of two colonies. The leafhoppers in these colonies had been obtained virus-free in one case by heat treatment and in the other by selection from insects collected in the field. To date, virus-free insects after feeding on the alfalfa plants have failed to infect any of 431 clover plants, whereas comparable insects, after feeding on club-leaf clover, have infected 148 of 406 test plants.

That the club-leaf virus multiplies in plants was shown by an experiment begun on November 12, 1943. Scions of *Vinca rosea* L. infected with the club-leaf virus were grafted on to healthy plants of the same kind. The incubation period is long, but to date thirty passages in series have been obtained. The symptoms of this disease in the flowers of *Vinca rosea* are unique, and they are the same after thirty passages as they are in plants freshly inoculated by insects.

Dilution of the virus present in the original female to $1:2{\cdot}8 \times 10^{26}$ without loss of infectivity must mean that the virus multiplied in the insect vector during its five-year stay on immune plants. Assuming a particle weight for the virus as low as 10,000,000 and a concentration in the insect as high as 1 per cent, the female would have contained only about 1×10^{13} virus particles. Even a mass of hydrogen weighing the same as the original female (1·7 mgm.) contains only about $5{\cdot}1 \times 10^{20}$ molecules.

Some of the implications of a virus multiplying in both plant and animal hosts have already been discussed[6]. It was pointed out that such a virus would really be both a plant and an animal virus, and would serve as a connecting link between the two groups; that the specificity of some insect transmission was probably dependent in part at least on whether the virus multiplied in a particular insect or not; that the incubation period in some leafhopper-virus combinations was probably due in part to multiplication of the virus in the vector and in part to the time required for its movement to the proper exit; that the occurrence of the same hypothetical large particle as virus precursor in both insect and plant was improbable. It seems likely that most, if not all, plant viruses with long incubation periods in their leafhopper vectors multiply in those vectors. Several of these viruses have been demonstrated to pass filters retaining bacteria[9–11] and some have been demonstrated to be much larger than other types of plant viruses that have been studied[11–13]. The only one of these actually seen under the electron microscope has the appearance of a little organism[12,13]. It is possible that the ability of viruses in this group to grow in more diverse physiological media than some other plant viruses is related to this greater particle size.

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PHYSIOLOGICAL MECHANISM OF MILK SECRETION

AN international colloquium on the physiology of milk secretion, organised by the Centre National de Recherche Scientifique, Paris, with the support of the Rockefeller Foundation, was held in the Institut de Biologie Médicale, Strasbourg, during August 22–29, delegates attending by invitation from Belgium, France, Switzerland, the United Kingdom and the United States. The scientific sessions occupied seven days, and senior members of the colloquium occupied the chair in turn. A feature of the meeting was the cordial atmosphere which obtained throughout. Members were unanimous in paying tribute to Prof. M. Klein, who was responsible for the organisation of the sessions and whose indefatigable efforts both before and during the colloquium were an important factor making for an outstandingly successful meeting. The papers presented at the colloquium will in due course be published in full, together with as much as possible of the discussions, in a volume to be issued by the Centre National de Recherche Scientifique.

The scientific proceedings were opened with a paper by Dr. J. Hammond, sen. (Great Britain), who considered various stages of mammary development in relation to the levels of progesterone and œstrogen existing in the body, a preponderance of progesterone being held to favour alveolar growth and a preponderance of œstrogen leading to a secretory condition. He contended that, in cattle, mammary growth from the time when sex hormones take over control from genetic organisers up to the twentieth week of the first pregnancy is decisive for subsequent milk yield. In the discussion on this paper, the lack of data on sex hormone-levels in cattle, which would enable such a theory to be put to test, was stressed. Dr. A. T. Cowie (Great Britain) described techniques used at the National Institute for Research in Dairying, Shinfield, for quantitatively studying mammary growth in the rat, guinea pig and goat, and reported recent experiments on artificially induced udder growth and lactation in spayed goats under the influence of œstrogen alone or plus progesterone.

Dr. L. Desclin (Belgium), discussing the effect of luteotrophic agents, prolactin and œstrogen, on the structure of the rat mammary gland, reported that in the presence of the ovary they promote alveolar growth but suppress secretion, while in its absence

they evoke a secretory condition in the alveolar epithelium. These same luteotrophic agents were also discussed in relation to mammary growth by Prof. M. Klein and Prof. G. Mayer (France), who described mammary growth responses to them in the presence of physiologically different types of corpora lutea. Prof. G. Mayer and Dr. R. Canivenc (France) described an interesting experiment in which a successful graft of placental tissue into the kidney of a female rat was accompanied by intense luteinization and the formation of mammary alveolar tissue engorged with milk, an outcome not easy to explain in terms of the results just mentioned. Hormonal factors influencing normal mammary growth were also subjected to a penetrating analysis by Dr. W. R. Lyons (United States), who showed slides illustrating the interplay of œstrogen and progesterone with anterior-pituitary and placental hormones in evoking pro-lactational mammary growth in the female rat.

It was particularly gratifying and appropriate that Dr. P. Stricker (France), who, working with F. Grueter in Strasbourg, discovered in 1928 the anterior-pituitary lactogenic hormone (prolactin), was able to be present to give a personal account of this important discovery, which opened a new era in lactational physiology. Two other papers on the hormonal control of the secretory phase may be mentioned at this point. Dr. W. O. Nelson (United States) described experiments on the hormonal initiation of lactation in the hypophysectomized guinea pig and brought forward new evidence that, at least in this species, œstrogens will inhibit lactation partly by depressing the prolactin output of the anterior lobe and partly by a direct action on the mammary gland. Prof. E. Letard and Dr. P. Szumowski (France) described experiments on the artificial induction of lactation in heifers by treatment with synthetic œstrogens, and the stimulation of such lactation, once established, by treatment with iodocasein. In the discussion on this latter paper, it was pointed out that the development in Great Britain of an improved method of synthesis of L-thyroxine in quantity has rendered iodocasein obsolete.

Two papers dealt with pituitary cytology in relation to the lactating state. Dr. L. Desclin (Belgium) described changes in anterior-pituitary cytology in relation to various factors, such as suckling, associated with the onset of lactation, and correlated these changes with the secretion of the luteotrophic and lactogenic hormone, prolactin. Morphological changes in pituitary tissue grafted into the kidney were also considered. Prof. R. Collin and Dr. J. Racadot (France) reported a correlation between the lactating state and the appearance of 'Herring' bodies in the hypophysis of the guinea pig.

Cytochemical studies on the mammary gland were discussed by Prof. J. Verne (France), who described the methods available and the results obtained by their use. The staining of ribonucleic acid, neutral fat and glycogen in mammary tissue was discussed, and the results of Dempsey *et al.*, who claim to have localized alkaline phosphatase in the capillary endothelium and myo-epithelium of the lactating gland, were described. Mr. K. C. Richardson (Great Britain), discussing this paper, wondered how far these last-mentioned results could be relied upon, in view of uncertainties now known to be associated with use of the Gomorri histoenzymatic technique for alkaline phosphatase.

A number of contributions on the biochemistry of milk secretion were presented. Dr. S. J. Folley (Great Britain) surveyed studies of the biochemical aspects of the endocrine control of lactation which have been carried out at Shinfield. These studies, at first mainly concerned with changes in milk composition, and later focused on the interplay between hormones and mammary gland enzymes, are now concentrated on the intermediary metabolism of mammary tissue. Some progress has been made in the study of the mechanism of milk fat synthesis, a process which seems to be to some extent under the control of insulin. Dr. F. H. Malpress (Northern Ireland) described experiments in which modern techniques have been applied to the question of *in vitro* lactose synthesis by mammary gland slices, and discussed his results in relation to various theoretical mechanisms of biological lactose synthesis, which remains one of the outstanding unsolved problems of carbohydrate biochemistry. The biochemistry of milk fat synthesis was discussed by Dr. T. H. French (Great Britain), who reported recent experiments on the metabolism of glucose and acetic acid by mammary gland slices, which point to the importance of the latter as a substrate for milk fat synthesis, particularly in the ruminant. He described tracer experiments carried out with G. Popják which establish the formation of the lower fatty acids of ruminant milk by condensation of C_2 units arising from acetate. Possibilities offered by the use of tracer isotopes in the study of milk secretion were considered by Prof. H. Simonnet (France), who reviewed previous studies in the field. He then described investigations with phosphorus-32 which indicate that the organic phosphorus of casein might originate from phosphopyruvate which could be transformed into phosphoserine by transamination and then integrated into the casein molecule. He went on to report results on the respective rates of incorporation of phosphorus-32 into deoxyribonucleic acid and ribonucleic acid in the mammary alveolar cell. The phosphorus of the nuclear deoxyribonucleic acid is less labile than that of the cytoplasmic ribonucleic acid, suggesting that milk is only synthesized when a definite relation between the rate of incorporation of phosphorus into the two types of nucleic acid is attained.

The physiology of milking and suckling was reviewed by Dr. M. H. I. Macaulay (Great Britain), who made a critical survey of the evidence in favour of the currently accepted neuro-hormonal theory of the so-called 'let-down' of milk. She concluded that this theory is by no means fully established yet. Her evaluation of experiments involving interference with the neurohypophysis, as by stalk-section or by interruption of the supraoptico-hypothalamic tract, was particularly valuable, and her essay served to mark the probable path for future progress in this field. In the subsequent discussion, Dr. J. Hammond reported that G. W. Harris and B. A. Cross had succeeded in evoking 'let-down' of milk in the lactating rabbit by direct electrical stimulation of the pituitary stalk. Mr. K. C. Richardson (Great Britain) gave a paper describing the morphology of the myo-epithelial cells forming a network round the mammary alveolus, cells which he has been able to figure adequately for the first time by means of a special silver-impregnation technique developed by him. He discussed the probable function of these cells in relation to the 'let-down' of milk, and presented evidence consistent with the view that during milking they actively contract and squeeze milk from the alveolar lumen rather than passively fold up as the alveoli collapse. He reminded those present at the colloquium that

direct and conclusive evidence that these cells contract in response to oxytocin (the essence of the neuro-hormonal theory) remains to be provided.

The clinical aspect of lactation was introduced by Dr. A. Ginglinger (France) in a paper in which he discussed factors other than hormonal ones which adversely affect lactation in women. Here the stress was mainly on social pressures arising from contemporary conditions of civilization which tend to make many women reluctant to suckle their infants. The lively discussion which followed ranged widely and touched also on the related subject of adverse psychological factors which, by interfering with the neurohormonal reflex concerned in milk ejection, could seriously prejudice the success of lactation. The colloquium concluded with a paper of unusual interest by Dr. R. Deanesly and Dr. A. S. Parkes (Great Britain), who have collected reports by anthropologists, medical missionaries and other such observers, of methods practised among primitive peoples, for the purpose of inducing lactation in non-parturient women or improving lactation already established. A common feature of most of these reports is the administration to the subject of certain plants or plant preparations often accompanied by manipulation of the nipples to mimic the suckling stimulus. Though well-authenticated confirmation of the galactogogue properties of such plant preparations is entirely lacking, nevertheless the authors considered that the reports are sufficiently consistent and their sources so widespread as to justify a well-controlled investigation of the whole question by an expedition composed of experts qualified in the relevant scientific fields. S. J. FOLLEY

INDUSTRIAL RADIOLOGY

THE Summer Meeting and Exhibition arranged by the Industrial Radiology Group of the Institute of Physics was held during the last week of July in the New Horticultural Hall, London. Accommodation was provided by the organising committee of the Technical Exhibition of the International Congress of Radiology held in London during the same period.

The meeting opened on July 25 with a paper by Mr. E. E. Smith (National Physical Laboratory) on "Industrial Aspects of Radiological Measurements". He discussed the changes likely to be made in fundamental units such as the 'röntgen' and the 'curie', and particularly how these will affect the industrial radiologist. When the recommendations of the International Congress are published, it is hoped to arrange a further meeting of the Group to discuss this subject.

On July 26 a paper was given by Dr. W. P. Grove (Radiochemical Centre, Amersham) on the "Handling and Transport of Gamma-Ray Sources for Radiography". Dr. Grove sketched the requirements for protecting both human beings and photographic materials from possible damage by gamma-radiation. Regulations have been drawn up, in the light of these requirements, regarding the use of public transport for the carriage of materials emitting gamma-radiation.

Mr. B. N. Clack (Radiochemical Centre, Amersham) spoke on "Natural and Artificial Sources of Gamma Radiation". After sketching the requirements for radiography of various materials, he indicated to what extent these have been achieved with both natural materials and with radioisotopes produced in the pile, and went on to show the trend in design of exposure containers. The lecture was illustrated by a number of slides of the plant at Amersham for making radiographic sources containing radon by adsorbing the gas on a small grain of charcoal in the manner originated by Dawson. Mr. Clack stated that radon is finding considerable application, because of the excellent quality of the radiographs obtained with it.

One session which proved of great interest was a symposium on industrial radiology in countries outside Britain. This opened with a paper by Dr. E. Dale-Trout (U.S.A.) on the "Characteristics of Lead Screens for Industrial Radiology", which contained much new and interesting information. A. Menetrier (Babcock and Wilcox, France) described the radiographic examination in France of welds in pressure vessels, and mentioned the general use of rod-type X-ray tubes placed inside the vessels for the examination of circumferential seams. He said that radiographic examination has enabled high-tensile steel to be used for welded tanks for the transportation of liquefied gases, thus enabling the weight to be reduced to one half. R. P. Barbotin (Kodak-Pathé, France) spoke of post-war difficulties, but said that rapid progress is now being made, and a high standard of radiographic technique can be ensured by the use of high-contrast fine-grain film. D. J. Binkhorst (Röntgen Technische Dienst, Holland) demonstrated a very convenient pack containing reference sets of penetrameter radiographs and comparative density films for use by inspectors when viewing radiographs. Mr. Å. Junghem (Sweden) described the work of the Central Institute of Radiology founded in Stockholm in 1937. He maintained that radiographic quality control need not be more expensive than mechanical testing, and said that it is proposed shortly in Sweden to substitute 'spot checks' by X-ray examination of structural welds in place of the usual routine mechanical tests. K. Koren (Norway) announced the formation about twelve months ago of a Central Institute in Norway for weld radiography; the chief application of industrial radiology in Norway is in the examination of pipe welds in hydro-electric plant. H. Vinter (Denmark), director of the Akademiet for de Technische Videns Kaber in Copenhagen, spoke of the work of this newly established Institute. He showed illustrations of a very unorthodox portable X-ray equipment, every part of which can be carried by one man and passed down the hatchway of a ship. The equipment was shown in use in various simple arrangements for the examination of ship welds. The design requirements of the equipment were that there should be no high-tension cables, no external coolers, and that it should be weather-proof; in fact, the control table will operate when immersed in water. The larger of two models operated at a maximum voltage of 170 kV. with a tube current of 2 milliamp.

At another meeting there was a symposium on the subject "What is the Use of Industrial Radiology?" The meeting opened with a thoughtful contribution by Mr. B. R. Byrne (Railway Executive, Southern Region), who emphasized the great care necessary by industrial organisations in the selection of radiographic equipment, in the training of operators and in the choice of consultants. Mr. G. T. Harris (Wm. Jessop and Sons, Ltd.) said that far more work is needed to correlate radiographic findings with the mechanical strength of the material, and to compare

various methods of non-destructive testing. He gave results of tests on turbine disk forgings of austenitic steel which showed satisfactory agreement between radiography, ultrasonic examination and tensile tests. Mr. J. C. Rockley (A.I.D. Test House, Harefield) referred to the well-known radiographic inspection of stressed castings for aircraft and described three other useful applications: detection of internal corrosion in aircraft fuel tanks; detection of faulty assembly of pitot pressure heads; detection of metallurgical defects in cartridge cases.

Dr. H. Harris (Babcock and Wilcox) stressed that the proper function of the radiographic examination of welded joints in pressure vessels is not so much to prove the acceptability of a particular weld as to correlate the weld with the test welds which are subject to mechanical tests. The greatest value of radiography is in developing welding processes rather than as a routine method of inspection.

Mr. H. S. Peiser (Hadfields, Ltd.) said that the fact that his firm is spending some £15,000 on a new radiological laboratory is evidence of its belief in the value of industrial radiology. Mr. J. F. Hinsley (Edgar Allen and Co., Ltd.) spoke of the expansion of the radiological facilities of the firm which he represents. He referred to a very important radiographic examination of castings for the housing of electric traction motors, etc., and described the methods of repairing surface irregularities by welding. Mr. S. M. Reisser (Murex, Ltd.) stressed the importance and the difficulty of attaining uniformity in radiographic interpretation, and emphasized that full details of radiographic technique are essential for accurate interpretation.

An exhibition of industrial radiology arranged by Dr. D. H. Follett (Science Museum) was held throughout the week. Some fifty exhibitors contributed to it, including the British Standards Institution, Mr. F. I. G. Rawlins of the National Gallery (who demonstrated the radiography of oil paintings), and Dr. C. Moss of the British Museum (who showed archæological radiographs). There was also a variety of radiographs illustrating the use of radio isotopes, auto-radiography, flash radiography, and radiography with a 1·4-MeV. synchrotron. There were several photographs of radiographic equipment, including one of an X-ray laboratory in a railway coach, shown by Mr. Knights and Mr. Dearden of the Railway Executive, Midland Region. Apparatus was shown for the radiographic examination of pipe welds. One piece of apparatus exhibited enabled the level of mercury in a steel manometer tube (made necessary because the pressure is too great for glass to withstand) to be read by sending a beam of gamma-rays through the tube and detecting it with an ionization chamber and cathode-ray tube. The Armament Research Establishment of the Ministry of Supply exhibited a new type of sensitive penetrameter devised for use in the radiographic examination of welded joints. The same Establishment also exhibited a container for use in gamma-radiography, made from tungsten alloy to minimize the transmitted radiation. The operator can allow gamma-rays to emerge when required by an automatically released 'stopper', while remaining shielded from the radiation himself. It is suitable for sources up to 1 curie in strength, and the source is automatically returned to a safe position when the container is raised on completion of an exposure. One of the radiographs, taken with an exposure of one-millionth of a second, showed a bullet travelling through water.

PLANT BREEDING IN GREAT BRITAIN

THE fourth annual conference of British plant breeders was held at the Scottish Plant Breeding Station, Corstorphine, Edinburgh, during August 3–4 and was attended by representatives of the John Innes Horticultural Institution, Bayfordbury; the Plant Breeding Institute, Cambridge; the Welsh Plant Breeding Station, Aberystwyth; the Plant Breeding Division, Ministry of Agriculture, Belfast; the National Vegetable Research Station, Wellesbourne; the Scottish Society for Research in Plant Breeding, Edinburgh; the Department of Agriculture for Scotland; and the Agricultural Research Council. At the conclusion of the conference, the invitation of Dr. C. D. Darlington, director of the John Innes Horticultural Institution, Bayfordbury, to hold the next conference at Bayfordbury in 1952 was accepted.

Sir John H. Milne Home welcomed the visitors on behalf of the board of directors of the Scottish Society for Research in Plant Breeding, and Sir Patrick Laird on behalf of the Department of Agriculture for Scotland. Mr. William Robb, director of research of the Scottish Society for Research in Plant Breeding, opened the proceedings by giving an account of the origin and organization of the Society, and the first morning of the conference was devoted to giving in turn an outline of the work of the various departments—cereal breeding by Mr. Robb, herbage breeding by Dr. J. W. Gregor, potato breeding by Dr. William Black, potato virus diseases investigations by Dr. G. Cockerham, and swede and sugar beet breeding by Dr. V. McM. Davey. The afternoon of August 3 and the morning and afternoon of August 4 were divided into five sessions, in which the party visited in turn the experimental plots of these departments, spending the morning of August 4 at the Potato Breeding Sub-Station at Boghall.

Cereals and Beans. In the breeding work with oats, the pedigree method of breeding has been mainly followed, but the 'bulk' method is now being tried. The main problems are to breed by hybridization and selection oats which are: productive, disease-resistant varieties highly resistant to lodging and having good quality milling grain which possesses resistance to germination at harvest time; hardy, early-ripening types for upland areas; and varieties showing a higher degree of tolerance of alkaline soil conditions than most standard varieties at present in cultivation.

A large number of unfixed hybrids were seen in plots in various stages of development, ranging from the first to the sixth generation. Attention was directed to various selections to illustrate the progress made in breeding for shorter straw and resistance to lodging, early-ripening types for upland areas, selections resistant to sprouting in the ear, and a selection adapted to alkaline soil.

Interest was shown in a number of transgressive segregates which illustrated wide genetical differences in length of straw and type of ear. The methods followed in testing the Society's new varieties at the Station, and at other centres in various parts of the country in co-operation with the three agricultural colleges in Scotland, were referred to, and the system followed in putting the Society's new varieties into commerce was outlined.

Mr. D. Cameron and Mr. H. D. Garvin demonstrated the work being done at the Station with barley and

beans, and described that on the production of polyploid oats by means of colchicine and acenaphthene. An *Avena sativa* having a duplicated set of chromosomes obtained by colchicine treatment of the seed, and a duplicated *Avena strigosa* obtained by the immersion of the coleoptile in colchicine solution were shown. Crosses between these two duplicated types have given a number of grains, presumed to be the amphidiploid.

A sterile hybrid between *A. barbata* and *A. strigosa* was shown, from which some twenty seeds have been obtained this year following acenaphthene treatment in 1949, and the material will be examined cytologically.

With barley, a problem is to breed a malting barley with a low dormancy and suitable for combine harvesting. Attention was directed to a few hybrids in the F_3 generation which had been selected for low dormancy at harvest time, from crosses between Scots Common barley types.

In field beans the object has been to produce early-ripening upstanding varieties with a high podding capacity and medium-sized round seeds suitable for machine sowing. Plants selected from an F_2 or from an open-pollinated mixed population were inbred for a number of generations by selfing them inside cotton bags to reduce variation, before multiplying the inbred line in spatial isolation to build up stocks sufficiently large for inclusion in field trials.

The Station equipment for threshing, cleaning, grading and husking oats was demonstrated to those interested in that aspect of the work.

Herbage. During the morning of August 3, Dr. J. W. Gregor discussed the relative merits of the bred strain and the regional race, and suggested that the usefulness of the regional race as a direct source of commercial seed should be given greater consideration.

In the afternoon, Dr. Gregor, Dr. P. J. Watson and Dr. F. Earnshaw enumerated some of the problems being investigated, and demonstrated some of the growing material. The investigations which were discussed are largely concerned with the major problem of utilizing hill vegetation efficiently. It was pointed out that where stock numbers are determined by the amount of winter food available, an increase in summer herbage production alone would be wasteful, and for this reason it was suggested that intensive cultivation of grass at the lowest elevation might meet the requirements of breeding animals better than extensive re-seeding of upland grazing. The problem, therefore, is primarily one of providing a rich supplementary feed for breeding cattle during the time when rough grazings remain unproductive; in other words, raising the level of nutrition by the complementary use of 'wild' and protein-rich cultivated herbage. What is wanted is a sown sward or swards able to provide protein-rich complementary grazing from mid-April until the end of May, and again in September and October, as well as silage or hay crops during the summer months. It was also mentioned that, given appropriate treatment, interesting changes in the vegetation can be effected and certain 'wild' plant communities can be used as protein-rich complementary grazing during the summer months.

Dr. Watson and Dr. Earnshaw dealt with some of the genecological investigations now in progress. This work, though primarily concerned with ecotypic differentiation and with the nature of the ecotype unit itself, has nevertheless a direct bearing upon the major problem of hill-land utilization. An endeavour is being made to study intensively the distribution of ecotypic variation along environmental gradients; and, in particular, attention is being paid to the spatial structure of intraspecific populations, and to the separation of ecotypic responses to altitudinal, edaphic and phytosocial gradients.

Potatoes. The potato-breeding work was described by Dr. Black, who explained that it is largely concerned with problems of disease resistance and with combining the different resistance qualities with the economic characters of commercial varieties. Natural resistance to each of the causal organisms of the more important diseases, blight, mosaics, leaf-roll, eelworm, scab and dry-rot, is to be found among the members of the potato family, and breeding experiments are designed to utilize the resistance factors as far as possible.

The problem of blight resistance was discussed in some detail, and methods of testing for resistance were demonstrated. In this work, seven different strains of the pathogen were employed for testing progenies derived from two main sources, namely, hybrids bred from *S. demissum* and *S. tuberosum*, and hybrids bred from *S. Rybinii*, *S. demissum* and *S. tuberosum*. Analysis of this material has shown that the blight resistance of *S. demissum* is controlled by at least four major independent genes which are inherited in simple Mendelian fashion.

The progress made in combining these genes with factors for resistance to other diseases was demonstrated in the field, where approximately a thousand selected seedlings have been grown in trial- and multiplication-plots for comparison as potential economic types.

Dr. J. C. Haigh demonstrated a number of species hybrids bred from *S. demissum*, *S. simplicifolium*, *S. acaule* and *S. tuberosum*, and explained their bearing on problems related to virus Y resistance and frost resistance. He also demonstrated the experiments laid out to study the effect of species and varieties on the soil population of the potato root eelworm.

Potato Virus Diseases Investigations. The subject of resistance to potato viruses was briefly reviewed by Dr. Cockerham, who dealt mainly with the genetic and breeding aspects of various forms of resistance to the *A*, *X*, *Y* and leaf-roll viruses. The methods of test used in recognizing and evaluating resistance characteristics were demonstrated, and attention was directed to a number of seedling varieties in which resistance to blight and virus diseases has been successfully combined. Current investigations being carried out by Miss T. M. R. McGhee and Mr. A. W. Macarthur on virus strains in relation to problems of resistance were explained in a demonstration of field-grown material infected with a series of strains of virus *X*.

Swedes and Sugar Beet. In discussing the breeding work with swedes (*Brassica Napus* v. *Napobrassica*), Dr. Davey described investigations which have been conducted since 1922 to test the possibilities of new breeding methods, and to attempt to obtain improved strains. Because the swede is potentially self-fertile, and seed propagated by the established trade method appears to be derived from both self- and cross-pollinations, a technique for the seeding of single plants in pollen-proof bags has been adopted. This technique was demonstrated.

At first, pedigree lines were established starting with plants selected from commercial crops, and some lines have been carried on for fourteen genera-

tions. Yield-trial results during the first twelve years indicated that about a third of the lines selected were worthless, while the remainder were not significantly better or worse than samples of their parent varieties. Improvement in uniformity was obtained, and it was concluded that the method might have some use in re-selecting contaminated stocks. Intervarietal crosses were made between the various swede types, and lines were selected which were also propagated by selfing. It was considered that these lines tended to become too uniform in their genetic constitution, so that after four generations it was difficult to effect any improvement in type or in performance. The intensity of inbreeding is now being lessened by intercrossing related phenotypes and by propagating one or more of the early generations as groups of mother plants in isolation. Selection for clubroot resistance is also being carried out on young plants grown in boxes of infected soil.

Investigations with sugar beet have been in progress for only three seasons. The yield of this crop in Scotland might be increased by sowing a few weeks before mid-April; but bolting would then become a serious consideration. Non-bolting sugar beet material under course of development at the Cambridge Plant Breeding Institute is being tested, and further selection and propagation is being carried out in collaboration with that Institute. A trial which included bolting and non-bolting material was demonstrated by Dr. Davey and Mr. F. J. W. England.

FIFTH INTERNATIONAL ANATOMICAL CONGRESS, 1950

THE Second World War was responsible for the cancellation of the Fifth International Anatomical Congress, which had been arranged to take place in Great Britain in 1940, and not until this year was it found possible to hold it. The previous Congress was in 1936 in Milan, so that another international meeting was much overdue; and thus the Fifth Congress was held in Oxford during July 25–28, under the auspices of the Anatomical Society of Great Britain and Northern Ireland, with Prof. W. E. Le Gros Clark as president.

Altogether, thirty-six countries were represented at the Congress, but, with the exception of Jugoslavia, which sent three members, there was no representation of any of the Eastern European countries. Even so, the 535 members who eventually came constituted a record attendance. A Government reception was held in Christ Church prior to the opening session, and the members were welcomed on behalf of the Government by Viscount Addison, who before leaving academic life was himself a professor of anatomy. In his presidential address the next day, Prof. Le Gros Clark reviewed current trends in the study of anatomy, and, among other things, emphasized the thinness of the largely artificial barrier between anatomy and physiology; his speech has been published in the *British Medical Journal* (ii, 233; 1950). At the University Convocation which followed the opening plenary session, honorary degrees were conferred on Lord Addison, Prof. G. W. Corner (Baltimore), Prof. M. W. Woerdeman (Amsterdam) and Dr. L. S. B. Leakey (Nairobi).

The subject-matter of the scientific sessions reflected the wide range of interests of modern anatomists, and emphasized the fundamental nature of the study of anatomy in relation to other biological subjects. Indeed, so varied was the content of the two hundred or so communications that it is difficult to make any useful summary; no official proceedings of the Congress are to be published. An attempt was made at rough classification into several groups: general anatomy, physical anthropology, neurology, histology, embryology and morphogenesis, and endocrinology; and, so far as possible, papers with related subject-matter were grouped together. This did not, however, prevent some strange juxtapositions. Thus, a paper on the mechanism of the interphalangeal joints in man was followed by one on the structure of the integument of the Anura; and a radiographic study of the mechanism of deglutition was succeeded by some remarks on the weak points of the lumbar region in Brazilian Indians.

In the section on neurology, which contained the greatest number of communications, there were two main groups, the first on the central nervous system, and the second on the peripheral nervous system and neurohistology. In addition, the greater part of two sessions concerned the peripheral parts of the autonomic system. The section on physical anthropology produced a spirited controversy regarding the origin and relationships of the Australopithecinæ, the observational evidence finding itself in conflict with the results of the more narrowly statistical approach. Among the other papers in this section were two dealing with the results so far obtained by the British–Kenya Miocene expedition. Under the heading of histology came several papers dealing with the application of phase-contrast microscopy to anatomical problems, and one whole session was devoted to papers dealing with bone. A number of new techniques were discussed, among them the use of microradiography and autoradiography. The section on embryology and morphogenesis included papers on experimental embryology and embryonic physiology as well as more purely descriptive papers. Lastly, in the endocrinology section, the main topics were the blood supply and functions of the pituitary and recent experimental work on the suprarenal cortex.

There were more than ninety demonstrations, involving some four hundred microscopes, and these, too, were roughly grouped together under headings. Here again, neurology was the heading under which came the greatest number of entries. Several films were shown, dealing with such diverse subjects as the tissue culture of osteoclasts and the recovery of skilled movements in monkeys after lesions in the motor cortex. An *ad hoc* discussion took place on the use of films in the teaching of normal anatomy, and in view of the difficulty, stressed by some Continental speakers, of obtaining material for dissection, it appears certain that there is scope for more and better teaching-films. The Congress resolved to form an international committee to approach the various and diverse sources known to be in possession of such films with the view to the formation of an international catalogue of available teaching material, and possibly the formation of a lending library.

It was also agreed to set up another committee, composed of delegates from the various national anatomical societies, to consider the difficult subject of modifying the present policy of *laisser-faire* with regard to anatomical terminology. The situation now is almost one of *tot homines, quot sententiæ*, since almost every nation has its own variant, usually, but

not invariably, stemming from the great Basle Nomina Anatomica of the early years of this century. Any attempt to produce uniformity is, however, fraught with considerable danger, since anatomical terminology enters into many fields of research and classification; and it was felt that great care must be exercised before deciding to inflict any changes on the long-suffering clinicians, who in many cases have already probably had to master at least three different terminologies. It was also agreed, however, that the subject is one of such importance that an approach should be made to the United Nations Educational, Scientific and Cultural Organisation for the purpose of appointing a paid secretary to the committee.

The Congress coincided happily with an exhibition in the Radcliffe Science Library reviewing the history of the teaching of anatomy at Oxford, and a booklet on this subject was presented to each member. The official languages of the Congress were English, French, German, Spanish and Italian, and the interpreters were kept busy. For the most part the delegates were accommodated in Oxford colleges, and during their visit there was no lack of entertainment. Many members took part in sightseeing tours and visits to places of interest; on the last night there was a dance at Oriel College, which was well attended. There was plenty of opportunity for the exchange of informal views and speculations between members who had not seen each other for many years, and the fullest possible use was made of it.

At the closing plenary session, the president referred to the death of Prof. H. C. Bazett, of the University of Pennsylvania, on his way to attend the Congress. It was proposed by Prof. J. Benoit, on behalf of the Association des Anatomistes de Langue Française, that the Sixth International Anatomical Congress should be held under the auspices of the Association, probably in Algiers, in 1955. This invitation was cordially accepted by the members, as was the proposal of Prof. N. L. Hoerr that the American Association of Anatomists should be responsible for the succeeding Congress. The members then dispersed, many of them to pay visits to other laboratories in Great Britain, and all having enjoyed a very pleasant and stimulating few days.

FLUORESCENT INKS FOR ADVERTISEMENT POSTERS

THE use in Great Britain in recent months of unusually brilliant coloured inks on advertisement posters has excited a good deal of interest and comment—some favourable and some otherwise. If, however, it be the purpose of a poster to invite attention, then these inks must be regarded as a success.

The underlying principle of the special inks used for these posters is that they contain a daylight fluorescent pigment which, because it fluoresces in the visible range, imparts the brilliance of colour. The fluorescent pigment is made by dissolving a small quantity of a fluorescent dyestuff in a transparent thermosetting resin (urea formaldehyde or phenol formaldehyde) and grinding the solid solution to a coarse powder. This pigment is then incorporated in a special printing ink containing coloured pigment and oil. Because fine grinding—the usual method of incorporating pigments in oil—destroys the fluorescent properties of the pigment, it is necessary that special inks be used, suitable only for a printing process known as 'silk screen printing'. The usual printing processes used for poster production—lithography and letterpress—demand finely ground inks, and for this reason the fluorescent inks cannot be used. Another reason for using the silk screen process is that it applies a much thicker film of ink to the paper than either lithography or letterpress, and this is an advantage, since the fluorescent inks are not 'permanent'. Even the best of the inks lose their effect after exposure for a month or so. Within limits, however, the thicker the ink film the more permanent is the ink, and hence the desire to print as much ink as possible.

The silk screen process has been used for a number of years for producing posters, showcards, folders, etc., where the number of copies is comparatively few; but the introduction of the new inks has extended the scale of operation considerably. The process is, in effect, a stencil printing process in which a thin ink—more like a paint than a normal printing ink—is forced through the mesh of a stencil made from a piece of silk stretched over a frame (synthetic fibres and wire mesh are also used). The stencil is made either by photographic means or is hand-prepared. The meshes in the image areas are left open, while those of the non-image areas are filled in. A stencil is made for each colour to be printed, and the ink is forced through the silk by means of a squeegee on to the sheet of paper beneath. Although the process can be made semi-automatic, a good deal of hand operation is involved, and hence to produce a large number of impressions is comparatively expensive.

The original patents covering these inks are American, and most of the inks used up to now have been of United States origin. The majority of ink makers in Great Britain, and on the Continent of Europe, are investigating their manufacture. The colours available to date are at the longer end of the spectrum—the reds, yellows and yellow-greens.

CENTRAL GLASS AND CERAMIC RESEARCH INSTITUTE OF INDIA

THE official opening of the Central Glass and Ceramic Research Institute of India at Calcutta by the Honourable Dr. B. C. Roy, Chief Minister, Government of West Bengal, on August 26, brings to fruition a well-planned scheme launched by the Council of Scientific and Industrial Research in India and removes the long-felt and urgent need for the establishment of such an institution in India. This is the fourth laboratory established by the Council to be declared open—the other three being the National Chemical Laboratory at Poona, the National Physical Laboratory at Delhi and the Fuel Research Institute at Dhanbad.

An account of the plans for this latest research institute was given in *Nature* of March 1, 1947. Although the foundation stone of the Institute was laid on December 24, 1945, by the late Sir Ardeshir Dalal, then member of the Viceroy's Executive Council in charge of the Department of Planning and Development, it was impossible to start work until September 1948. Only the technological block had

been constructed in 1948, where work has been in progress since then; important contributions on the availability and improvement in the quality of Indian raw materials for the glass and ceramic industries have already been made; a detailed account of these investigations was recently published. Researches on coloured glass, sintered glass and foam glass are in progress; the work on foam glass has aroused great interest.

The laboratory is located in Jadavpur, a southern suburb of Calcutta, and occupies a total floor area of about 45,700 sq. ft. The Institute with its imposing glass tower is a carefully designed and well-equipped laboratory providing facilities for team-work and for specialized research in glass and ceramics. The building consists of two blocks: the main block comprising laboratories for precision work, the library and the museum, and the technological block comprising units for processing raw materials, furnaces, workshops, etc. The building has many notable features. Special mention may be made of the armoured-plate glass doors, the first of their kind to be installed in India. The vestibule is decorated with a mural in cut glass in a single piece measuring about 6 ft. × 4 ft. and depicting the glass-blower's craft and potter's wheel, and an enamelled panel bearing the Council's insignia and the inspiring words of the Prime Minister of India, Pandit Jawaharlal Nehru, who is also president of the Council of Scientific and Industrial Research: "Do it now! I am not interested in excuses for delays, I am interested only in things done."

The museum (entrances to which are curtained by artistic glass fabrics) houses, besides specimens of raw materials and finished products of the glass and ceramic industries, many rare exhibits of historic interest. Excavated pieces of ancient Indian art from Mohenjodaro and Harappa, glass articles of the Moghul, Napoleonic, pre-Victorian and Victorian periods, specimens of historic interest from Westminster Abbey, Switzerland, France and Sweden, provide an array of exhibits spanning the long stretch of man's history. Of special interest to men of science are a double-ended discharge tube belonging to de la Rive, a Woulfe's bottle used by Davy and Faraday, an original heavy-glass prism made by Faraday, porcelain prisms and glass semi-cylinders employed by Sir J. C. Bose in his investigations, and a desiccator, a stone bottle and a measuring cylinder belonging to Sir P. C. Rây. A specimen of glass produced by the first atomic bomb explosion at New Mexico has been presented to the museum.

In a message read at the opening ceremony, the Prime Minister, Pandit Nehru, said: "The Central Glass and Ceramic Research Institute deals essentially with one of the most important applications of science. It will, I hope, play an important role in developing not only the glass industry in India, but many of its ramifications. Above all, I hope that this laboratory will nurture and spread the spirit of science so that we may grow out of our narrow selves and thus raise ourselves and our country to higher levels of thought and achievement."

Describing the need for such a laboratory, the Honourable Mr. Harekrushna Mahatab, Minister for Industry and Supply, Government of India, and vice-president of the Council of Scientific and Industrial Research, said: "The need of such an institute was felt during the last war. The human mind has been trained in such a way that unless there is a violent shock in the shape of a war, it is not stirred up to think of scientific research in various fields for the uplift of the human society as a whole. How one wishes that in peace-time, too, various researches were made and money could be available in abundance for the purpose."

Sir Shanti Swarup Bhatnagar, director of scientific and industrial research, Government of India, said: "The Council of Scientific and Industrial Research realized that glass and ceramic industries of India must be scientifically developed if they are to play the role they must, in the onward march of progress and achievement which, in our conviction, is India's destiny. . . . We have chosen Calcutta for the location of the Institute as it is one of the principal centres of the glass and ceramic industry. For the establishment of a successful glass and ceramic industry, we are as much dependent on science and technology as on decorative and creative art requiring delicate touches which only deft hands can impart; and as we know that Bengal possesses artistic talent which few other places can equal as well as scientific acumen of a high order, we feel we have acted rightly in locating the Institute here."

His Excellency Dr. K. N. Katju, Governor of West Bengal, presided at the opening, and in his address he blamed the politicians for the misuse of scientific discoveries. "We are now living in the atomic age fearful of what the future may unfold, and sometimes people blame the scientists for inventing and perfecting instruments of tremendous destruction, destruction as gigantic as is caused by an earthquake. For this abuse and perversion of human knowledge acquired by conquest over Nature we must not hold the scientists responsible. Responsibility for this must be placed fairly and squarely on the so-called statesmen of the world and on the people led or misled by them. Scientists discover, and this discovery has been a continuous process throughout the ages. It is for the people to decide how these discoveries are to be utilized, for the betterment of mankind or its destruction."

In declaring the Institute open, the Honourable Dr. B. C. Roy commented on the importance of having the right men in charge. They must be able to "create enthusiasm among the trainees and confidence in those who would be benefited by their research work. Dr. Atma Ram and his associates have established a reputation and I hope and trust that this Institute will have a succession of achievements to its credit."

Dr. Atma Ram, joint director of the Institute, defining the functions of the Institute, said that "although the functions of the laboratory are to some extent objective in character, one of the chief aims of the Institute "will obviously be fundamental research, because unless the workers are devoted to increasing the bounds of knowledge they will not be able to apply scientific ideas in the best way. The experience of laboratories elsewhere is that problems for fundamental research often reveal themselves during investigations of industrial problems. There is a host of such instances in glass and ceramics. At the same time, the Institute should not remain isolated and indifferent to the needs of the country and would endeavour to do its best to help the industry."

Some four thousand people attended the opening ceremony, including ministers and officials of Central and State Governments, eminent men of science, representatives of the glass and ceramic industries and others.

LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications

Structure within Polyhedra Associated with Insect Virus Diseases

For some time we have been examining with the electron microscope thin sections of caterpillars infected with their polyhedral diseases. In this way it is possible to follow the development of the disease, to see the crystal-like polyhedra as they are formed *in situ* and to observe the fine structure of their contents.

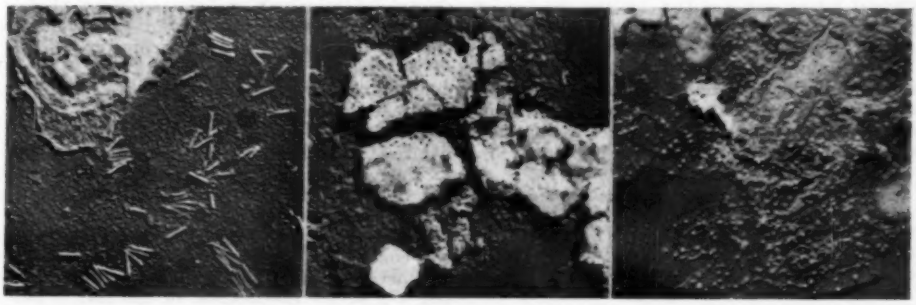

Fig. 1. Membrane and residual contents of an alkali-disintegrated polyhedral body from a diseased larva of *P. dominula*. The rod-shaped virus elementary bodies of uniform diameter are scattered over the substrate and can be seen within the membrane together with two of the thicker rods (near the bottom of the membrane) from which these virus particles come, as well as others in various stages of disintegration. Positive print. × 11,000

Fig. 2. Pitted debris of polyhedra treated with sodium carbonate, from *A. villaca*. The holes have essentially uniform diameters of the same order of magnitude as flattened spheres often observed on the surrounding substrate. Positive print. × 8,500

Fig. 3. Spherical particles, which may be elementary particles of virus, obtained by the alkaline disintegration of polyhedral bodies developed within a larva of virus-diseased *A. caja*. Positive print. × 8,500

Bergold[1,2] has obtained electron micrographs showing thin rods freed when polyhedra of the silkworm larva, *B. mori*, of the gypsy moth caterpillar, *P. dispar*, and of the nun moth caterpillar, *L. monacha*, are treated with dilute sodium carbonate. Presumably these are elementary bodies of virus. Similar rods have been obtained by Steinhaus and his co-workers[3,4] from polyhedra of the alfalfa caterpillar, the western yellow-striped army worm and the California oak worm. Treatment of the polyhedra from some of, but not all, the species of caterpillars which we have studied reveals similar rods.

Such rods have been obtained from the scarlet tiger moth caterpillar, *P. dominula*, and the currant moth caterpillar, *A. grossulariata*. In both these cases, alkaline disintegration has revealed thick as well as the thin elementary rods within and issuing from the membranes that enveloped the polyhedra (Fig. 1). As in this figure, the thin rods are frequently small groups in parallel array. In a few places the thick rods, which always have approximately the same length as the thin rods, are themselves disintegrating to reveal thin ones within them.

Polyhedra from other caterpillars, some belonging to species closely related to the foregoing, do not seem to contain these rods. Thus when the polyhedra from the cream spot tiger (*Arctia villaca*), the garden tiger (*A. caja*) moth caterpillars and the caterpillars of *Rhypara purpurata* are treated with sodium carbonate, there remain hollow shells of the polyhedra pitted with a large number of holes of very uniform diameter (Fig. 2). On the substrate surrounding these disintegrated polyhedra there can sometimes be seen clusters of spherical bodies having about the same diameter as the holes (Fig. 3). These spheres, often flattened, occur singly and in short chains. Similar holes and spheres can be seen within the polyhedra in sectioned tissues of the caterpillar itself. Unlike the polyhedra that yield rods, these usually show no evidence of enveloping membranes.

In all the caterpillars discussed here, the polyhedra developed within nuclei which may become so distended as nearly to fill their cells. This is true whether or not the rod-like particles are found. Fig. 4, from

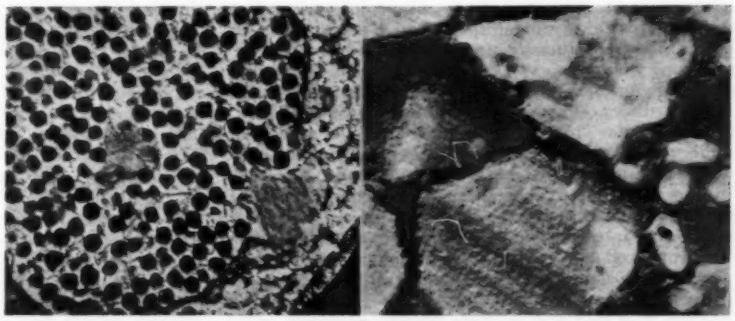

Fig. 4. Section showing part of a cell from a virus-diseased larva of *A. grossulariata* with almost all the nucleoplasm replaced by polyhedral bodies. Negative print. × 2,000

Fig. 5. Section through parts of spherical polyhedra within a cell of a diseased larva of *A. villaca*. The spherical pits disseminated through these bodies are easily seen. Positive print. × 11,000

a section through a diseased currant moth caterpillar, is typical of what is seen at low magnification under the electron microscope. The crystal-like outlines of the polyhedra are very evident in these sections. Fig. 5 shows several sectioned polyhedra from a cream spot tiger caterpillar. They exhibit the same pitting that is seen after alkali treatment. Sometimes there are protuberances in place of the holes. These facts, taken in connexion with what is seen in Figs. 2 and 3, suggest that the inclusions in these polyhedra are little spheres.

In no instance thus far have we found any indication of the spherical forms and pitted polyhedral matrix in species yielding rods, or *vice versa*. This suggests that the virus diseases of caterpillars that produce crystal-like polyhedral inclusions may fall into at least two different groups. That exhibiting the spherical forms and typified by the disease of the cream spot tiger moth caterpillar has not previously been described.

We are continuing these combined studies of the virus polyhedra from a number of related species of caterpillars both in section and after disintegration. A more detailed report of the results already obtained will be published elsewhere.

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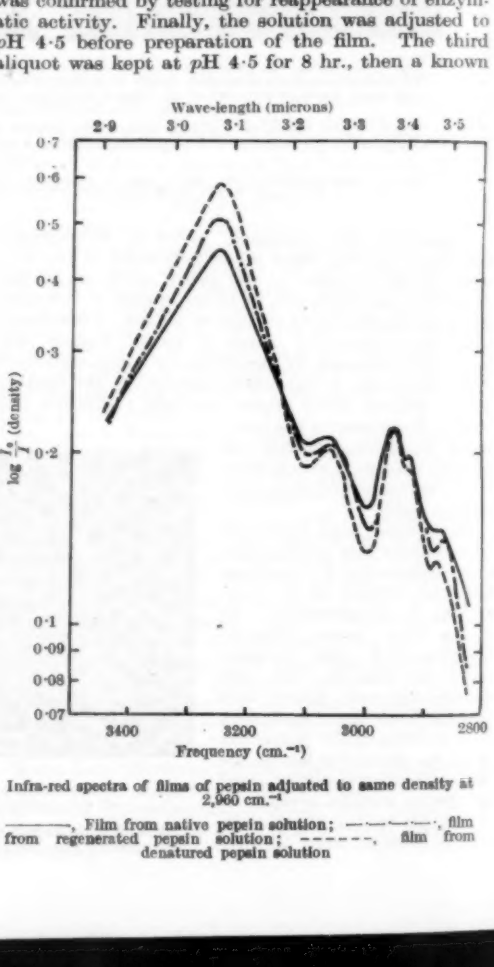
Infra-Red Spectra of Films of Native and Denatured Pepsin

WE report here some observations on the infra-red absorption of films prepared by drying native, denatured, and regenerated pepsin solutions. On thermodynamic grounds[1] the alkali denaturation of pepsin molecules unrestricted in space (dilute aqueous solution) would be expected to involve the breaking of a large number of intra-molecular hydrogen bonds. As yet, direct evidence as to the formation of new intermolecular hydrogen bonds between uncoiled molecules is lacking. Differences in the infra-red absorption spectra of native and denatured pepsin in the range of hydrogen-bonding frequencies can, with reasonable assurance, be assumed to represent evidence for overall changes in hydrogen bonding. The infra-red spectra of films of pepsin and other enzymes measured in the wave-length region 2–15 microns[2,3] show, in addition to the strong bands around 3, 6 and 6·5 microns always obtained with proteins and polypeptides, several less intense absorption bands in both the 3-micron region and at wave-lengths longer than 6·6 microns. In this communication we are concerned only with the region 3,400–2,800 cm.$^{-1}$ (2·9–3·6 microns), in which the spectral measurements were made using calcium fluoride and lithium fluoride prisms, since this is a region of absorption by hydrogen-bonding frequencies.

Crystalline pepsin from two commercial sources (Armour and Worthington) was used in the preparation of native, denatured, and regenerated pepsin solutions. 300 mgm. of each of the crystalline pepsin preparations was dissolved in 5·0 ml. water acidified to *p*H 4·5 with dilute hydrochloric acid, and dialysed against water acidified to *p*H 4·5 for 24 hr. at + 2° C. Following dialysis, the pepsin solutions were made up to 25 ml. volume, and again adjusted to *p*H 4·5. Three 5·0-ml. aliquots of each was placed in three stoppered Erlenmeyer flasks and allowed to come to equilibrium at room temperature. One aliquot was then brought to *p*H 8·5 by addition of a known amount of alkali through a capillary, and kept at this *p*H for 8 hr. at room temperature. At the end of this period it was brought to *p*H 4·5 and the denaturation was confirmed by testing for loss of enzymatic activity.

The second aliquot was submitted to treatment identical with the first; but after standing at *p*H 8·5 at room temperature for 4 hr., it was adjusted to *p*H 7·5 with acid, then gradually brought to *p*H 6·8 over a period of 4 hr., by adding minute quantities of acid through a capillary pipette. The regeneration was confirmed by testing for reappearance of enzymatic activity. Finally, the solution was adjusted to *p*H 4·5 before preparation of the film. The third aliquot was kept at *p*H 4·5 for 8 hr., then a known



Infra-red spectra of films of pepsin adjusted to same density at 2,960 cm.$^{-1}$

————, Film from native pepsin solution; — — — —, film from regenerated pepsin solution; – – – – –, film from denatured pepsin solution

amount of salt was added to duplicate the calculated amount of salt formed in the two other aliquots in the course of adjustment of *p*H to 8·5 and then back to *p*H 4·5. This third aliquot was used as the native pepsin sample in each case, since enzymatic activity proved to be intact.

Enzymatic activity was tested by incubating 1·0 ml. of each of the three aliquots at the end of the experiment with 2·0 ml. of 2 per cent denatured bovine albumin as the substrate (heat-denatured at 83° C. for 10 min.) and 0·5 ml. of 0·09 *N* hydrochloric acid. Proteolytic activity was determined (*a*) by formol titration, and (*b*) by measurement of the decrease of turbidity with increasing enzymatic hydrolysis of the substrate. In this manner 40 per cent activity was found in the regenerated Armour pepsin and 25 per cent in the regenerated Worthington pepsin, assuming the values obtained for the native pepsin to be 100 per cent and the denatured, zero. These solutions of native, denatured and regenerated pepsin prepared in identical manner from two different sources of crystalline pepsin and all adjusted to the same final *p*H, were used in the preparation of films for infra-red absorption studies.

Typical spectral data are reproduced herewith. Since the films were all prepared by evaporating or casting a few drops of the pepsin solutions on silver chloride disks and then drying in a vacuum desiccator over phosphorus pentoxide at 3° C. similar to the way previously described for nucleic acids[4], the thickness of the films varied somewhat from preparation to preparation. This variation in thickness has been compensated for by making the assumptions that the number of C—H bonds per molecule are constant and also that the 2,960-cm.$^{-1}$ C—H stretching frequency obeys Beer's law independently of whether the protein is in a native or denatured state. If one makes these two assumptions, the first of which is probably exactly valid and the second approximately valid over a relatively limited thickness range, then one may adjust the intensity of the rest of the spectra to fit the use of the 2,960-cm.$^{-1}$ absorption band as an internal standard[5]. This procedure was followed with several different pepsin preparations by plotting density on log paper and reducing to a common density at 2,960 cm.$^{-1}$. In each case it was noted that the relative absorption of the film obtained from denatured pepsin solutions was higher in the 3,260-cm.$^{-1}$ region than that of films cast from native pepsin solutions, while the absorption of the films obtained from the regenerated pepsin lay always at some intermediate value. In our experiments the (adjusted) absorption differences in the intensity of the 3,260 cm.$^{-1}$ band were of the order of 0·05–0·25 density units.

It seems established, mainly by the careful studies of Sutherland and his co-workers on a variety of simple amides as well as on certain peptides and proteins[6,7], that the 3,260-cm.$^{-1}$ band is associated with a hydrogen-bonded N—H frequency. Our measurements show an increase in the intensity of this frequency as the percentage of residual native pepsin decreases, thus indicating an increase (in the denatured state) in the intensity or number of the bonds with which this frequency is associated. In denatured protein films, the probability of orientation of the uncoiled pepsin molecule, and the institution of the mesomorphic state through intermolecular bonding along adjacent uncoiled molecules, are greatly enhanced. This appears to be supported by our results.

We are indebted to Dr. R. C. Lord for interesting discussions on this subject, and to Dr. V. Z. Williams for the use of a lithium fluoride prism.

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Alteration of Collagen Structure by Irradiation with Electrons

In endeavouring to induce shrinkage in collagen by irradiation with electrons, structural alterations in the material were determined from the low-angle X-ray diffraction patterns of samples which had been exposed in the beam of an electron accelerator. Previous experiments have shown that, when collagen is permitted to shrink hydrothermally, the average intensity of the low-angle diffraction pattern decreases with the degree to which the sample has been allowed to shrink. The elongation at which this pattern disappears is dependent upon the temperature at which the shrinkage takes place. Thus, the intensity of the low-angle diffraction pattern can be used as a means of determining the amount of structural damage brought about by electron irradiation.

The electron beam used to irradiate the collagen samples was derived from a resonant cavity pulsed by a 10-cm., one-megawatt type 4J33 magnetron. The magnetron was pulsed with one-microsecond pulses at 333 cycles per second, giving a 0·00033 duty factor. With this duty factor, the average beam current output was about 1·2 microamp. at a maximum energy of 0·63 MeV. Spectrometer tests indicated that the beam energy was not monochromatic but possessed a maximum intensity of 0·3 MeV. The rate at which the samples were irradiated was determined to be of the order of 2,000 r. per sec. This value was obtained by extrapolating Victoreen 'r' meter measurements to a distance of 1·5 cm. from the window.

Both wet and dry samples of untreated kangaroo tail tendon collagen were exposed to the electron beam for varying amounts of time. All samples were held in a small clamp which could be mounted in the low-angle diffraction camera. This held the fibres parallel and ensured that the X-ray beam would be directed at the same region of the fibres which had been exposed to electrons. All samples were dried before their low-angle patterns were photographed. The X-ray diffraction results are listed in the accompanying table.

It was observed that wet samples which were not clamped curled toward the electron source after about

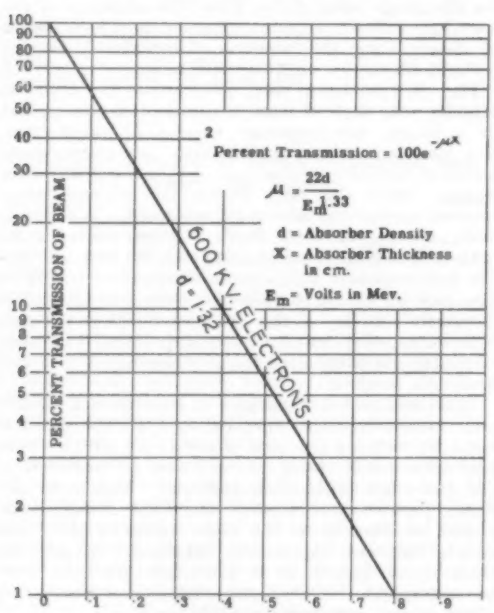
Sample	Electron exposure (min.)	Integrated time pulses (sec.)	Diffraction pattern intensity	Estimated crystallinity* (per cent)
Dry collagen	none		good	100
Wet collagen	10	0·2	faint	30
Wet collagen	20	0·4	very faint	10
Wet collagen	45	0·9	none	0
Dry collagen	30	0·6	medium	50
Dry collagen†	30	0·6	none	0

* Based on 100 per cent = amount of crystallinity in dry untreated collagen.

† Soaked in water after electron exposure.

a 15-min. exposure. After the same amount of exposure, fibres of clamped wet samples showed a tendency to break, curl and shorten lengthwise. This curling of wet samples can be explained by the fact that maximum ionization occurs at one-third of the maximum distance penetrated by the beam in the irradiated sample[1]. Shrinkage is, therefore, initiated in the upper half, and uniform shrinkage of the entire fibre is never achieved because, by the time sufficient ionization has occurred at the lower surface, the upper section of the fibre has absorbed so much energy that gelatinization has taken place and the material dissolves. The absorption curve shown in the accompanying graph indicates that about 98 per cent of the electron beam is absorbed in penetrating collagen samples, which were 0·75 mm. in diameter. Attempts to measure the rise of temperature of the collagen during irradiation indicated that it was only a small fraction of a degree.

It is interesting to note that, in the dry sample, a 30-min. exposure to electrons produced no observable alterations in the physical appearance of the material other than a marked yellow discoloration, and the X-ray diffraction pattern showed evidence that a large percentage of crystallinity remained in the sample. Yet, when this sample was immersed in water for a few hours, most of the material dissolved and all that remained was a thin gelatinous film which exhibited only an amorphous low-angle diffraction pattern.


PERCENT TRANSMISSION OF BEAM
Collagen fibre diameter (mm.)
Percent Transmission = 100e^-μx
μ = 22d / E_m^1.33
d = Absorber Density
X = Absorber Thickness in cm.
E_m = Volts in Mev.
600 KV. ELECTRONS
d = 1·32

Absorption of electrons by dry collagen

The above findings may be of significance to those employing an electron microscope in the study of collagen. Although the electron energy in an electron microscope is considerably less than that used above, it may still be sufficient to cause appreciable changes in the specimen. Considering the minute cross-section of the electron microscope samples, any change which might be produced by electron radiation would occur practically instantaneously. It is possible that such an effect might introduce uncertainty in interpreting electron micrographs in terms of the true structure of collagen.

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Effect of Neutron Irradiation on the Thermal Conductivity of a Quartz Crystal at Low Temperature

THE thermal conductivity of crystals is very structure-sensitive, particularly at low temperatures. In the case of dielectric crystals, this has been demonstrated by de Haas and Biermasz[1], who measured the effect of heat treatment on the conductivity of a quartz crystal in the liquid-hydrogen temperature region.

In the present experiments lattice defects, consisting of displaced atoms, have been produced in a quartz crystal by irradiation with fast neutrons in a pile, and we have measured the changes in conductivity after several successive periods of irradiation and after subsequent annealing. The extra thermal resistance is due to these displaced atoms and is not associated with any nuclear transformations which may be produced in small quantities during the irradiation.

The temperature-range of the measurements, 2°–90° K., is covered more fully than has been done before in heat conductivity measurements, and the curves shown in Fig. 1 each comprise 15 to 25 measured points.

The theory of the thermal conductivity of dielectric crystals was developed by Debye[3], Peierls[3], Pomeranchuk[4] and Casimir[5]. At low temperatures the thermal resistance can be regarded, to a first approximation, as being composed additively of the resistances due to the following processes, which are responsible for the scattering of phonons (lattice waves): (1) boundary scattering, which produces a resistance $W_B \propto L^{-1} T^{-3}$, where T is the absolute temperature and L is the external dimension of the crystal[5]; (2) 'umklapp' processes, which produce a resistance $W_U \propto T^{-2} \exp(-\theta/2T)$, where θ is the Debye temperature[3]; (3) scattering by various disorders, such as lattice defects which produce a resistance $W_D \propto \varepsilon T^n$, where ε is the defect concentration and n is a constant which never exceeds + 1.

One of us[6] has combined the rigorous method of Peierls with the approach of Pomeranchuk and has applied the theory to the conductivity of crystals and glasses. In the case of quartz crystals, an analysis on the basis of the present theory of the results of de Haas and Biermasz[1] and of the present experiments shows that W_B is the chief factor determining the resistance below 10° K. and W_U the chief factor above that temperature. W_D is only an appreciable fraction of the total resistance in the neighbourhood of 10° K. The resistance is mainly determined by the mean free path of the transverse waves.

In the case of quartz glass, this theory shows that the conductivity at high temperatures is mainly due to the transverse waves and is proportional to the specific heat (as pointed out by Kittel[7]). At low temperatures, the contribution from longitudinal waves predominates and gives rise to a component which is proportional to T at the lowest temperatures, reaches a maximum and then falls off. The combination of these two components produces the conductivity, as measured before by one of us[6], and shown in Fig. 1.

It can be seen from Fig. 1 that, with increasing irradiation, there is a gradual transition in the form of the temperature-dependence of conductivity from that of the original crystal to that of the glass. This can be explained as follows. Fast neutrons produce cascades of displaced atoms, some of which are clustered together in small regions, while others are separated by many atomic diameters from neighbouring defects. After the first irradiation the crystal shows a resistance additional to the normal resistance which, above 15° K., can be interpreted as the resistance due to the numerous single lattice defects.

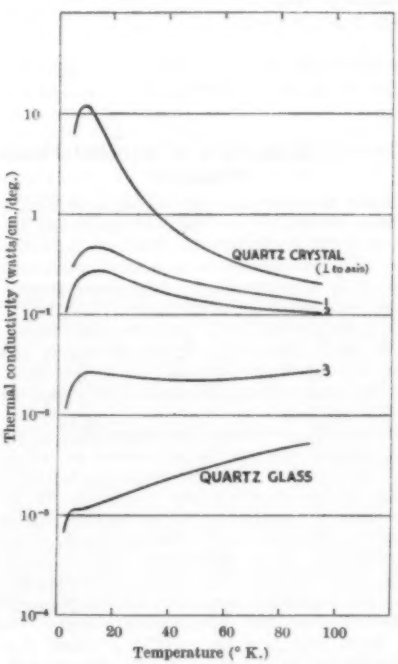

Fig. 1. Thermal conductivity of quartz crystal, irradiated quartz crystal and quartz glass. Cumulative irradiation doses: (1) 1 unit; (2) 2·4 units; (3) 19 units

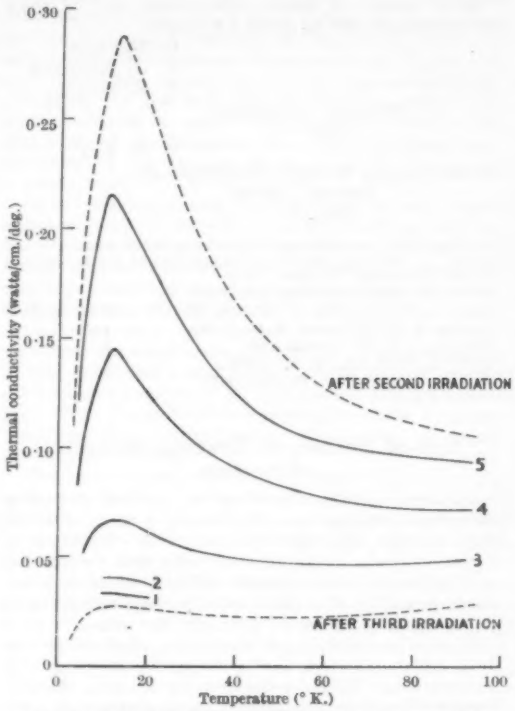

Fig. 2. Thermal conductivity of irradiated quartz crystal after successive annealings: (1) 300° C. for 8 hr.; (2) 400° C. for 6 hr.; (3) 510° C. for 6 hr.; (4) 565° C. for 6 hr.; (5) 540° C. for 60 hr.

Below 15° K., however, the extra resistance is in the nature of a boundary resistance, with a value of L of the order of 10^{-2} cm. This can be interpreted as due to the clusters scattering phonons independently of their frequency, giving an apparent size-resistance with $1/L \simeq \sigma N$, where N is the number of clusters in unit volume and σ is the cluster cross-section.

After prolonged irradiation the number of single defects is so large that there is interference between neighbouring defects, and the temperature-dependence of the defect resistance gradually changes to the case of glass, that is, the scattering by defects becomes less dependent on frequency. Also, at low temperatures the longitudinal component of conductivity becomes appreciable, compared with the transverse component, resulting in a peak at 10° K. We can regard the irradiated crystal as a 'dilute glass'.

The cumulative irradiation doses after the three periods of irradiation are in the ratios 1 : 2·4 : 19, and the induced resistances at the lower temperatures are in roughly these ratios. During the first irradiation the thermal neutron dose was $1{\cdot}8 \times 10^{18}$ per square cm.

The effect of annealing the crystal, at various temperatures, after the last irradiation, is being studied. The conductivities after annealing are shown in Fig. 2. So far, the crystal has not been heated above 573° C., the transition temperature from α- to β-quartz. The shape of the conductivity-temperature curve after the last annealing is slightly different from that after the second irradiation and suggests that a smaller percentage of defects are now clustered together.

More details of these experiments and of their interpretation will be given elsewhere.

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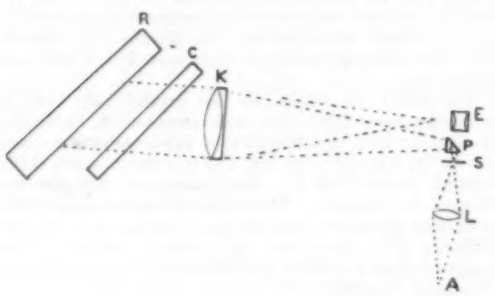
Use of Diffraction Gratings Ruled on Cylinders

I have recently described[1] a method of ruling diffraction gratings on cylinders by a method which gives results substantially free from the periodic errors otherwise difficult to avoid; and by coating such cylinders with a plastic pellicle, which is afterwards removed, it is possible to prepare flat gratings in hardened gelatine on optically flat glass.

I have recently found that it is possible to use these ruled cylinders as the dispersing element in a spectroscope. When a flat grating is used, the collimating lens (or a reflector) ensures that the rays shall fall on the grating at the same angle. In using the cylinder grating as a dispersing element, this condition is fulfilled by the use of a cylindrical lens placed obliquely in the beam of parallel rays from the collimating lens, the axis of the cylinder grating being set accurately parallel to the axis of the cylindrical lens and at right-angles to the plane of the slit. A simple disposition of the optical parts involved, which illustrates the method, is shown in the accompanying diagram. In this the Littrow arrangement is used, the same lens being used as collimator and telescope and the light from the slit being directed towards the collimating lens by means of a small right-angle reflecting prism.

Observations of the image are made with an eyepiece either just above or below or to one side of the right-angle prism. Light from the source A is brought to a focus on the slit S by means of the condensing lens L and is reflected towards the collimating lens K by means of the prism P. The rays then fall on the cylindrical lens C, the axis of which is parallel to the axis of the ruled cylinder R. The distance from C to R is adjusted so that rays proceeding from a point in the centre of the slit would be focused as a line on the axis of the ruled cylinder R. The axis of the cylinder R is disposed, in relation to the optic axis of the collimator, in such a way that the rays fall on the ruled cylinder at right-angles to the individual flat facets of the cuts made by the diamond in ruling the grating, the order of the spectrum observed in the eyepiece E being thus that order into which the greater part of the energy is thrown. It will be seen that the rays fall on the ruled cylinder at the same angle.



This arrangement has been tried with a cylinder grating one inch in diameter ruled with 4,000 lines to the inch, and excellent definition was obtained in the fourth order, which showed a fairly good 'blaze'. A similar arrangement, in which lenses are replaced by reflectors, follows on obvious lines and should be applicable to instruments designed for use in the infra-red. The resolving power and dispersion can be evaluated in precisely the same manner as if a plane grating were used; but whereas in the case of a plane grating the light-gathering power is proportional to the area of the ruled surface, with the method described above the light-gathering power is independent of the diameter of the ruled cylinder. With flat gratings of very large ruled area, the total distance travelled by the ruling diamond may be so great as to impair the diamond through wear before the whole area can be covered; but with the cylinder grating this difficulty should be greatly reduced. It should also be possible to bore cylinder gratings axially and so maintain a constant temperature by circulation of water.

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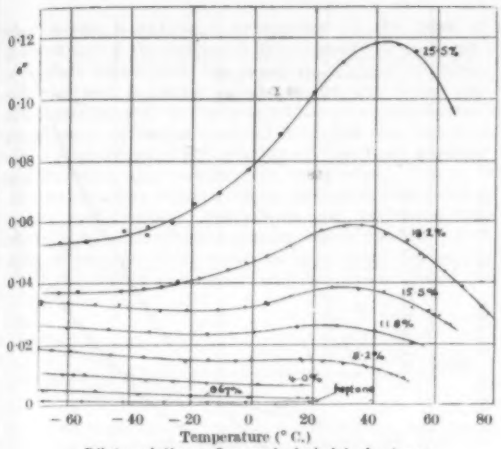
Dielectric Relaxation of Alcohol–Heptane Mixtures

It is well known[1] that pure alcohols exhibit a large dielectric absorption at radio frequencies, together with a very much smaller absorption in the centimetre region. For measurements at a fixed wave-length of 10 cm., this corresponds to the occurrence of loss peaks at temperatures of the order of + 100° C. and − 100° C. respectively. In practice, the low-temperature loss peak thus found would be largely obscured by the loss at high temperatures; but this is no longer the case when the alcohol is dissolved in a non-polar solvent.

A 10-cm. H_{01} resonator has been used to measure the dielectric absorption of solutions of *n*-amyl alcohol in heptane. Curves are given in the accompanying graph showing the variation of ε'' with temperature for a number of concentrations between 0·6 and 25 mol. per cent. The curves show how the 'low-frequency' loss maximum falls rapidly with dilution, such that at the intermediate concentration of 15·5 per cent the losses due to the separate relaxation mechanisms are approximately equal. On the other hand, the loss at − 70° C., which for these concentrations is almost entirely due to the high-frequency mechanism, falls proportionately with concentration. At very low concentrations (less than



Dilute solutions of *n*-amyl alcohol in heptane.
Concentrations in moles per cent

1 per cent) the 'low-frequency' loss disappears and only the 'high-frequency' loss remains.

Similar behaviour has been found for mixtures of *n*-butyl alcohol and *n*-propyl alcohol in heptane. It is hoped to publish these curves, together with a more detailed consideration of the results, in the near future.

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Structure of a Deformed Metallic Grain

A number of years ago, Wood[1] suggested that the circumferential spreading of the sharp X-ray diffraction spots from annealed grains into continuous arcs along the Debye circle on deformation could be best accounted for by supposing that the grains break down into a number of fragments oriented at small angles to each other. Experiments on the deformation of polycrystalline aluminium at elevated temperatures under creep conditions have confirmed that the individual grains break down into more or less perfect crystalline elements, the degree of perfection and size of which increase with increasing temperature and decreasing strain-rate[2,3]. It appears that the continuity of the Debye arcs from aluminium deformed rapidly at room temperature is due to the smallness of the fragment size. Further direct confirmation of this view has been obtained recently by a micro-beam X-ray technique[4].

Cahn[5] has suggested that, at least in bent single crystals of zinc, the lattice is bent continuously by the deformation and that, on heating, the crystal breaks up into a number of distinct crystalline elements. Some previous research on the deformation and recovery of high-purity polycrystalline aluminium, however, had suggested that the discrete structure observed after recovery was present already in the deformed state[6]. This led to similar experiments being performed on high-purity polycrystalline zinc. The purpose of this note is to show that zinc confirms the fragmentation theory in a rather spectacular manner.

The experiments consisted in lightly (up to 3·5 per cent) deforming coarse-grained electro-polished specimens in tension at various temperatures and examining them both microscopically and by the usual X-ray back-reflexion method.

Fig. 1 shows the diffraction pattern from a specimen stretched 3·1 per cent at 21° C. The X-ray pattern from the same area in the original annealed condition consisted of five sharp spots, each from individual grains. Since each arc is very discontinuous, it appears that each grain has broken down into a number of quite large fragments tilted relatively to each other. Microscopic examination also revealed that a number of grains manifested an inner structure, as shown by sharp changes in direction of the slip lines.

After elongating a similar specimen the same amount at 200° C., the diffraction pattern shown in Fig. 2 was obtained, each arc exhibiting a more discrete structure than in the previous case. The corresponding photomicrograph, Fig. 3, illustrates the typical surface appearance of the specimen. Before deformation, the grain showed no trace of internal structures. After deformation, as shown, the grain in the lower centre of photograph manifests a most marked inner structure and no trace of slip. The

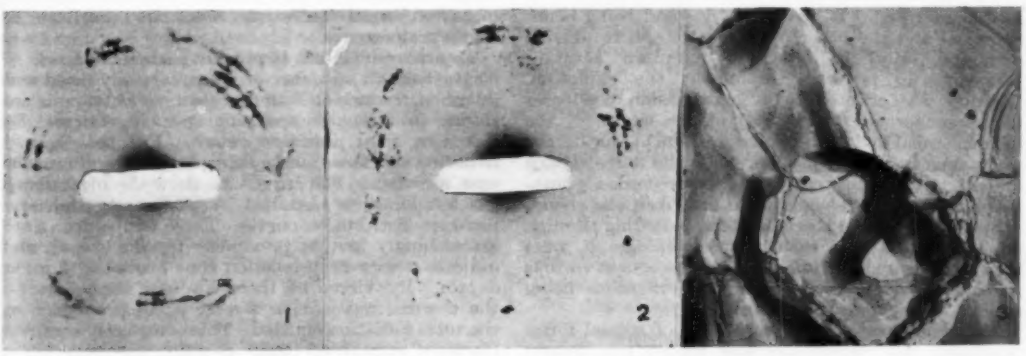

Fig. 1. Diffraction pattern from polycrystalline zinc elongated 3·1 per cent at 21° C.
Fig. 2. Diffraction pattern from polycrystalline zinc elongated 3·1 per cent at 200° C.
Fig. 3. Photomicrograph from the area corresponding to Fig. 2. × 75

neighbouring grains show slip and also traces of a sub-structure. The original grain boundaries are characterized by their 'thickening' due to the deformation. It was demonstrated that the effect was not superficial by electropolishing the surface and re-etching, which brought out the original grain boundaries and the network of sub-boundaries within the grains corresponding with the boundaries of the inner structural elements.

On the basis of these results, it may be concluded that, upon the deformation of polycrystalline zinc, the grains break down into a number of fragments, the degree of perfection, and probably the size, of which increase with increasing temperature of deformation.

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Thermal Radiation and Chemiluminescence from Explosion Flame Gases

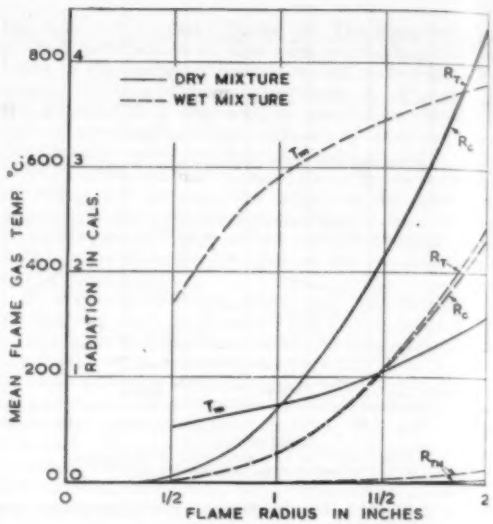
The radiation emitted during explosions of gaseous inflammable mixtures has been studied by several workers, notably David[1] and Garner[2], yet few data exist nor has finality been reached in deciding whether the radiation is purely thermal in origin or whether the phenomenon of chemiluminescence plays a part. In relation to carbon monoxide–oxygen explosions, Garner concluded that the radiation was partly of chemiluminescent origin; but his method precluded the quantitative assessment of the relative importance of each, nor has his conclusion been everywhere accepted[3].

We have recently undertaken a quantitative study of the radiation emitted from explosions and have been able to show that chemiluminescence plays a major part in the case of carbon monoxide – air explosions.

The explosion vessel used was a steel cylinder 5 in. in diameter and 7 ft. in length, one end being hemispherical and the other open to atmosphere (during explosion only) in order to maintain constant (atmospheric) pressure throughout the explosion. Ignition was effected by a high-tension condenser discharge across a spark gap at the centre of the hemispherical end. The flame movement during the early stages of the explosion, while the flame retains a very nearly spherical front, was recorded photographically using a lens system described elsewhere[4].

Special resistance thermometers, recording through an A.C. bridge on a cathode ray oscillograph, were used to measure the flame-gas temperatures at various radii from the source of ignition, corrections being applied as previously described[5].

The radiation bolometer used was of special form, consisting of 0·001-in. diameter copper wire wound non-inductively in the form of a small cone and held in an ebonite holder. The bolometer was mounted behind a fluorite window in the wall of the tube so as to view the whole spherical flame during the early stages of explosion. The change of resistance of the bolometer was recorded on the cathode ray oscillograph simultaneously with the flame-temperature traces. With the direct calibration of the bolometer and the measured transmission efficiency of the fluorite window, the radiation received by the bolometer could be computed, and from the known solid angle subtended by the bolometer, the total radiation emitted by the growing ball of flame could be calculated at any instant.



After the flame had travelled down the tube to the open end, the reaction was shown to be completed in the flame gases near the centre of ignition by using catalytically active resistance elements[6]. The radiation then received by the bolometer from the hot flame gases must have been of purely thermal origin. The amount of this thermal radiation emitted per unit quantity of the products of combustion was computed from the geometry of the tube and bolometer for various mean gas temperatures during cooling. From these values the thermal radiation emitted by the expanding spherical flame up to a flame radius of 2 in. could be estimated. The difference between these estimates of the thermal radiation and the measured total radiation must be ascribed to chemiluminescence.

Typical results for a 45 per cent carbon monoxide + 55 per cent air mixture (*a*) when carefully dried and (*b*) when containing 0·25 per cent water vapour are shown in the accompanying graph. Curves R_T represent total radiation, curves R_{Th} the thermal radiation and those marked R_C give the chemiluminescent radiation. The curves T_m show the mean flame gas temperatures obtained by integrating the temperature-distribution curves. These temperatures are astonishingly low, as previously foreshadowed[7], and indicate a very deep reaction zone exceeding 2 in. in depth. By virtue of these low gas temperatures, the thermal radiation is a very small proportion of the total radiation emitted. This completely confirms Garner's conclusion that chemiluminescence does occur in the reaction zone.

In both wet and dry mixture explosions, the chemiluminescent radiation at all flame radii repres-

ents almost a constant proportion of the heat of combustion of the inflamed gas, namely, 2 per cent. Yet at all flame radii the reaction is more complete with the wet mixture, as shown by the mean gas temperatures, and we estimate that the total chemiluminescent radiation emitted from the wet mixture will be approximately a quarter of that from the dry mixture after the reaction is completed.

A continuation of this work using carbon monoxide – oxygen and carbon disulphide – air mixtures has shown that chemiluminescence again occurs, but forms a smaller proportion of the total radiation due to the higher mean gas temperatures attained.

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Oxidation by Photochemical Electron Transfer Excitation

Stein and Weiss[1] have shown that hydroxyl radicals can be detected in solution by their ability to oxidize the benzene nucleus, leading to the formation of phenol derivatives. These hydroxyl radicals were produced *in situ* both by irradiation of aqueous substrate solutions with X-rays, α-rays, etc., and by the use of Fenton's reagent. Similar results were obtained with the latter by Merz and Waters[2]. Evans and Uri[3] have shown that irradiation of aqueous solutions of ion pair complexes such as $Fe^{3+}OH^-$, $Fe^{3+}Cl^-$, $Fe^{3+}F^-$, etc., with ultra-violet light (300–400 mμ) produces atoms or free radicals in solution able to initiate the polymerization of vinyl compounds. Experimental evidence indicates that the ion-pair complexes postulated by Rabinowitch and Stockmayer[4] are the photochemically active entities in ferric salt solutions. In the light of these findings, we investigated the effect of monochromatic light of wave-length 365 mμ on aqueous solutions of benzoic acid in the presence of ferric ion-pair complexes. Benzoic acid was chosen as substrate because the formation of the very intensely coloured ferric salicylate complex is convenient for a photometric determination.

The kinetics of ferrous ion formation and of salicylate complex formation can be interpreted on the basis of the scheme:

$$Fe^{3+}\,OH^- \underset{k_d}{\overset{h\nu(k_a)}{\rightleftharpoons}} Fe^{3+}\,OH$$

$$Fe^{3+}\,OH \xrightarrow{k_2} Fe^{2+} + OH$$

$$OH + C_6H_5\,.\,COOH \xrightarrow{k_1} HOH + \cdot C_6H_4\,.\,COOH$$

$$OH + \cdot C_6H_4\,.\,COOH \xrightarrow{k_1} HO\,.\,C_6H_4\,.\,COOH$$

$$Fe^{2+} + OH \xrightarrow{k_3} Fe^{3+} + OH^-.$$

Stationary state kinetics would lead to the following equations (assuming $k_t \gg k_i$):

$$-\frac{d[S]}{dt} = \frac{1}{2}\cdot\frac{d[Fe^{2+}]}{dt} = \frac{1}{2}\cdot\frac{k_2 k_a I}{k_d + k_3}\left(\frac{2k_i[S]}{k_3[Fe^{2+}] + 2k_i[S]}\right).$$

Ferrous ion and salicylic acid in the reaction mixture were determined colorimetrically, the former with *o*-phenanthroline in the presence of excess fluoride and the latter by measuring the concentration of the ferric salicylate complex formed. At a concentration $\geqslant 10^{-3}\,M$ of benzoic acid, the ratio of ferrous ion and salicylic acid formed is found to be about 5.

Spectroscopic analysis of the reaction mixture shows that not only salicylic acid but also the meta- and para-hydroxy acids are formed and are present in the molar ratio of approximately 2 : 2 : 1. This is in keeping with the above ratio of $d[Fe^{2+}]/d[\text{salicylate}] \sim 5$. It seems that the probability of free radical attack is independent of the position in the nucleus of benzoic acid. We have not been able to detect the formation of diphenic acids under these conditions.

The following additional features throw some light on both the identity of the photochemically active species and the free radical substitution in the benzene nucleus.

In the presence of N perchloric acid, no salicylic acid is formed, giving further evidence that $Fe^{3+}OH^-$ is the active species and not the hydrated ferric ion. Irradiation of $Fe^{3+}Cl^-$ or $Fe^{3+}F^-$ which led to the polymerization of vinyl compounds does not produce salicylic acid but presumably halogeno-benzoic acids, while ferric ion is being reduced to ferrous ion. This shows that under these conditions the reactions $Cl + OH^- \rightarrow Cl^- + OH$ ($\Delta H \simeq -3$ kcal., $\Delta S \simeq +20$ e.u.), and $F + OH^- \rightarrow F^- + OH$ ($\Delta H \simeq -30$ kcal., $\Delta S \simeq 0$) are too slow to compete with the direct attack of the substrate. This might be expected when taking into consideration the low concentration of OH^-. Moreover, one may conclude that the reactions $Cl + H_2O \rightarrow Cl^- + OH + H^+$ and $F + H_2O \rightarrow F^- + OH + H^+$ are also too slow to compete with the atom + substrate reaction.

When *p*-toluic acid is used instead of benzoic acid, 4-methylsalicylic acid (producing a similar complex with ferric ion) is formed. The amount, however, is considerably less than that found in the case of benzoic acid, although the formation of ferrous ion is similar under comparable conditions. This observation might suggest that side-chain oxidation is occurring.

A more detailed account of this study will be published later.

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[1] Stein and Weiss, *Nature*, **161**, 650 (1948); *J. Chem. Soc.*, 2074 (1949). (with Loebl, H.); *ibid.*, 3241 (with Farmer, F. T.); *ibid.*, 3245, 3254, 3256 (1949).
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Enzymatic Dephosphorylation of Ovalbumin and Plakalbumin

THE work presented here was designed primarily to test the suggestion of Linderstrøm-Lang and Ottesen[1] that the failure of the phosphorus content of ovalbumin to correspond to an integral number of atoms of this element per mole could be correlated with the electrophoretic complexity[2] of this protein. Thus a typical preparation of ovalbumin consisted of 82 per cent of the A_1 component, 18 per cent of A_2 and contained $1{\cdot}8_1$ atoms of phosphorus per mole of 44,000. If it is assumed that A_1 contains two atoms of phosphorus per mole and A_2 one atom per mole, the computed phosphorus content of this preparation is $2 \times 0{\cdot}82 + 1 \times 0{\cdot}18 = 1{\cdot}8_2$, in good agreement with the observed value of $1{\cdot}8_1$. Additional evidence for this assumption and further insight into the nature of the phosphate groups in ovalbumin have also been obtained from the enzymatic dephosphorylation described below.

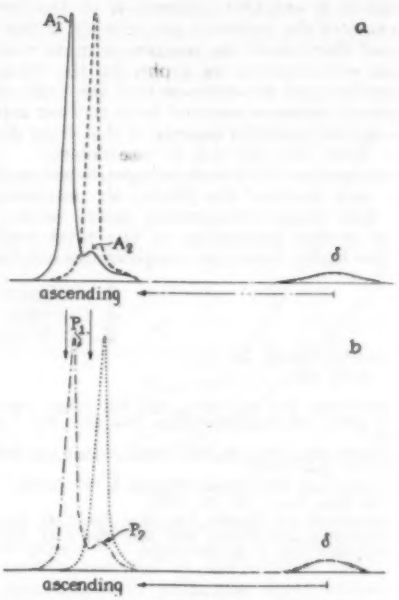
The ovalbumins with different phosphorus contents should not be confused, however, with plakalbumin[1,3], a protein derived from ovalbumin with the aid of a proteolytic enzyme from *B. subtilis*. Moreover, electrophoretic analyses made in this Laboratory[5,6] have shown that plakalbumin consists of two components, P_1 and P_2, in the same proportion as that of the two constituents, A_1 and A_2, of the parent substance, ovalbumin, but with lower mobilities. Since plakalbumin has the same phosphorus content as ovalbumin[1,4], it must be assumed that P_1 also contains two atoms of phosphorus per mole and P_2 one atom[6]. The properties of the proteins discussed in this communication, and on which their identification is based, are summarized in the accompanying table.

	Ovalbumin			Plakalbumin		
Electrophoretic components	A_1	A_2	A_3	P_1	P_2	P_3
$u \times 10^{5*}$	−5·9	−4·8	−4·3	−5·5	−4·4	−3·7
Crystal form	Needles			Plates		
Atoms phosphorus per mole of protein†	2	1	0	2	1	0

* Electrophoresis carried out in sodium phosphate buffer at *p*H 6·8 and 0·1 ionic strength.

† Assuming a protein molecular weight of 44,000.

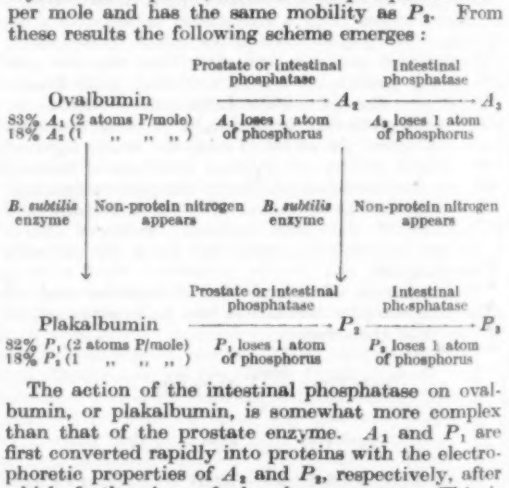
The experimental attack on this problem has been made possible by generous samples of a purified prostate phosphatase, and also one of intestinal origin, provided by Dr. Gerhard Schmidt of the Boston Dispensary. On exposure of 10 ml. of a 5 per cent salt-free ovalbumin solution of *p*H 5·4 to 2·5 mgm. of prostate phosphatase at 37° C. for 5 hr., A_1 was found to be converted, with a loss of one atom of phosphorus, into a component having the mobility of A_2. This protein crystallizes as needles. Under the same experimental conditions, but using plakalbumin as the substrate, P_1 is transformed into a protein with the mobility of P_2 that crystallizes as plates. In Fig. *a* are superimposed the tracings of the electrophoretic patterns of ovalbumin before and after treatment with the prostate phosphatase, whereas Fig. *b* shows the patterns of plakalbumin before and after dephosphorylation with this enzyme. Since these patterns were obtained at a constant total protein concentration of 1 per cent in sodium phosphate buffer of *p*H 6·8 and an ionic strength 0·1, at a potential gradient of 6·4 volts per cm. for 12,600 sec., com-



Superimposed tracings of the electrophoretic patterns of (*a*) —— ovalbumin, – – – – dephosphorylated ovalbumin; and of (*b*) – · – · – plakalbumin, ····· dephosphorylated plakalbumin. The arrows in Fig. *b* indicate the boundary positions of A_1 and A_2, respectively

parison of Figs. *a* and *b* also indicates the difference of the mobilities of ovalbumin and plakalbumin, respectively[5]. Exposure to the enzyme for longer periods, namely, 12 and 24 hr. does not alter the result.

If A_2, prepared by dephosphorylation of ovalbumin as described above, is now treated with the proteolytic enzyme from *B. subtilis*, about 2 per cent non-protein nitrogen is liberated. The resulting protein crystallizes as plates, contains one phosphorus atom per mole and has the same mobility as P_2. From these results the following scheme emerges:



The action of the intestinal phosphatase on ovalbumin, or plakalbumin, is somewhat more complex than that of the prostate enzyme. A_1 and P_1 are first converted rapidly into proteins with the electrophoretic properties of A_2 and P_2, respectively, after which further loss of phosphorus occurs. This is reflected by the appearance in the electrophoretic patterns of new components, A_3 and P_3, the mobilities of which at *p*H 6·8 are less than A_2 and P_2. This

reaction, although of enzymatic nature, is slow and it has not been possible yet to prepare pure A_2 or P_2. Chemical analyses of the reaction mixtures show that A_2 and P_2 do not contain phosphorus. This fact, and the failure of the prostate enzyme to remove the second phosphorus of A_1 and P_1, indicate a difference in the chemical nature of the two phosphorus-containing groups of these proteins.

In conclusion, it should be pointed out that only three properties, namely, electrophoretic mobility, crystal form and phosphorus content, have been used to identify the products of mild enzymatic degradation of ovalbumin. Although chemical differences other than the phosphorus content may exist between A_1, A_2 and A_3 and between P_1, P_2 and P_3, it is probable that the mobility increments are largely due to the loss of the charged phosphate groups. Moreover, additional confirmation that the P_2 obtained by dephosphorylation of P_1 is identical with that obtained by proteolysis of A_2 would be of interest in this connexion.

I wish to express my thanks to Dr. L. G. Longsworth for help in preparing this manuscript.

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Rockefeller Institute for Medical Research,
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Protein Activation of Streptolysin 'O'

MANY studies have been made of streptococcal hæmolysins. Todd[1] demonstrated essential differences between the '*O*' and '*S*' forms of streptolysin. Herbert and Todd[2] made a more exhaustive study of streptolysin '*O*' and characterized it as a protein capable of hæmolysing red cells, only, however, after activation with —SH-containing reducing agents.

During experiments involving the use of certain streptococcal preparations and albumen and globulin fractions of serum, it was observed that rabbit red-cell suspensions were hæmolysed in the presence of mixtures of the streptococcal preparation and serum albumin.

Streptolysin '*O*' prepared in Todd–Hewitt broth[3] and partially purified by Herbert and Todd's[2] method was found to be activated not only by —SH-containing reducing agents such as thioglycollic acid, cysteine, etc., but also by serum albumin.

Albumin fractions separated from serum by 50 per cent saturation with ammonium sulphate consistently showed an activating effect when allowed to stand at room temperature with inactive streptolysin '*O*'. The fractions were dialysed before testing, to remove ammonium sulphate, and were made isotonic by the addition of sodium chloride, their volumes being corrected to that of the original volume of serum used for precipitation. The effect of these samples upon inactive streptolysin '*O*' was determined by mixing 0·5-ml. volumes of the fraction under test with varying doses of previously standardized inactive lysin in equal volumes. The mixtures were allowed to stand five to ten minutes at room temperature before the addition of 0·5 ml. of 3 per cent washed rabbit red-cell suspension. Buffer-saline mixture at *p*H 6·6 was used as diluent. Controls of inactivated lysin and lysin activated with sodium thioglycollate were included with each series of tests. Hæmolysis was observed after one hour in the water-bath at 37° C.

Albumin fractions prepared from human, bovine (bovine crystalline albumin : Amour and Co.), horse and rabbit serum all showed varying though definite activation of streptolysin '*O*'. The intact sera and the globulins of these species, with the exception of one sample of rabbit globulin, were without effect. Two samples of ovalbumin and a muscle protein solution were also without effect. If iodoacetate was added to the albumin – streptolysin mixtures, activation was either abolished or markedly reduced.

Herbert and Todd[2] suggest that streptolysin '*O*' contains disulphide linkages which can be reversibly reduced to sulphydryl groups, the —S—S— form being hæmolytically inactive whereas the —SH form is active. An interpretation of the activation of streptolysin '*O*' by reducing agents having free —SH groups has been made on this basis[2].

The activation of streptolysin '*O*' by serum albumin is most probably due to readily available —SH groups in the latter, since such activation was prevented by iodoacetate. Anson[4] and Olcott and Fraenkel-Conrat[5], in reviews of properties of protein groups, point out that the reactivity of —SH groups of proteins varies with the protein and upon the amount of denaturation it has undergone. The inability of whole serum and the globulin fractions to activate streptolysin '*O*' might be explained on this basis; however, the presence of small amounts of anti-streptolysin '*O*' found in the globulin of even 'normal' sera provides an alternative explanation.

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Biological Oxidation of Iron in Soil

Lees and Quastel[1] described a soil perfusion apparatus in which a liquid could be passed continuously through a column of soil under conditions of maximum aeration. The apparatus as modified by Audus[2] has been used in the present investigations on the biological oxidation of iron in soil.

Biological oxidation of divalent iron in soil. 20-gm. columns of air-dried, crumbed soil maintained at *p*H 3·0 were perfused with solutions of ferrous sulphate. Daily analyses showed that apart from a small initial fixation (probably caused by the formation of ferrous phosphate) the concentration of ferrous ions in the perfusate steadily fell. As divalent iron salts are not oxidized in air at a *p*H below 5·0, it would appear that the recorded effect must be attributed to biological action of the soil flora.

This biological action does not occur in the perfusate itself, but is limited to the soil. It is probably bound up with the favourable environment presented to the micro-organisms by the optimum diffusion of oxygen in the film of fluid coating the soil particles.

In some soils it has been found that the rate of oxidation is initially constant, probably due to a high incidence of the specific iron-oxidizing micro-organ-

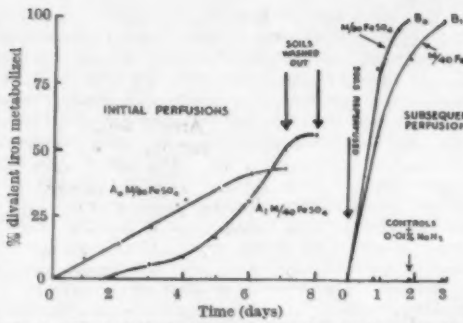

Fig. 1. Effect of divalent iron concentration on its metabolism in normal air-dried soils, and the influence of sodium azide on this metabolism.
(*A*) 20 gm. soil perfused with 200 ml. ferrous sulphate sol. A_0 *M*/80 $FeSO_4$, A_1 *M*/40 $FeSO_4$ (azide controls deducted).
(*B*) Divalent iron metabolism in same soils on subsequent perfusion

isms in the soil; in other soils, after an initial lag-phase (where no divalent iron is metabolized), the concentration of ferrous cations afterwards falls at an increasing rate. This lag-phase is variable and depends on the nature of the soil under investigation.

It also appears that the initial concentration of the divalent iron perfused may influence the lag-phase before oxidation takes place (see Fig. 1, *A*). This lag-phase of the ferrous iron oxidizing micro-organisms, is followed by a subsequent oxidation of the cation, presumably by the development of micro-organisms which are adapted to metabolize this initial high iron concentration. Investigations into these phenomena will be published later.

If, after an initial perfusion, the soil is washed with distilled water and re-perfused with a fresh solution of ferrous salt, no lag phase is observed, and the rate of ferrous cation disappearance from the perfusate is constant (Fig. 1, *B*).

Thus this soil may be compared with an enzyme specific for ferrous iron metabolism, and the influence of various metabolites on this system can be readily studied.

That the ferrous iron is oxidized to trivalent iron is readily shown by an enriched soil the base-exchange complex of which is already saturated with trivalent iron. If such an enriched soil is perfused with divalent iron, Table 1 shows that the fall in ferrous iron concentration in the perfusate is equal to the rise in concentration of ferric ions.

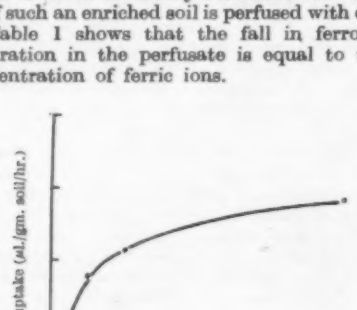

Fig. 2. Influence of divalent iron concentration on rate of oxygen uptake by air-dried enriched soil

Table 1

20 gm. soil (enriched)	Fe++ present/ml. perfusate	Fe+++ present/ml. perfusate
(1) perfused 200 ml. $FeSO_4$ (*M*/80)	600 µgm.	0
(2) after 24 hr.	50 ,,	550 µgm.

Effects of a biological poison on ferrous oxidation. A cell poison such as sodium azide, when added at a low concentration to a soil perfusate containing ferrous sulphate, will completely inhibit all biological ferrous oxidation (Fig. 1 and Table 2).

Table 2

20 gm. soil (enriched)	Fe++ metabolized 24 hr./ml.
(*a*) perfused 200 ml. *M*/80 $FeSO_4$	550 µgm.
(*b*) *M*/80 $FeSO_4$ + 0·01 per cent azide	0

Oxygen uptake studies of enriched soils. It has been found that the enriched soils described will retain their enriched nature when air-dried and stored at 0° C. These soils may be studied using a modified Warburg technique (unpublished) developed by Quastel and his colleagues at the Agricultural Research Council Unit of Soil Metabolism.

It can be shown that rates of oxygen uptake by an enriched soil following the addition of a divalent iron salt are dependent on the concentration of the divalent iron present (see Fig. 2). This technique also readily shows the influence of poisons on the enzyme systems which are activated by the divalent iron compounds.

Table 3 shows the inhibitory influence of three well-known enzyme poisons, sodium azide, mercuric chloride and iodoacetic acid, on oxygen uptake.

Table 3

Metabolite added to 4 gm. enriched soil	Oxygen uptake (µl./gm. soil/hr.)	% Inhibition
Expt. 1		
(i) 1·5 ml. *M*/34 $FeSO_4$	15·75	—
(ii) 1·5 ml. *M*/34 $FeSO_4$ + 0·01 per cent sodium azide	2·73	82·6
Expt. 2		
(i) 1·5 ml. *M*/20 $FeSO_4$	11·25	—
(ii) 1·5 ml. *M*/20 $FeSO_4$ + 0·1 per cent iodoacetic acid	2·25	80·0
(iii) 1·5 ml. *M*/20 $FeSO_4$ + 0·1 per cent mercuric chloride	1·95	82·6

It is hoped later to apply the methods to an examination of biological aspects of the problems of the availability of iron in soils to plants.

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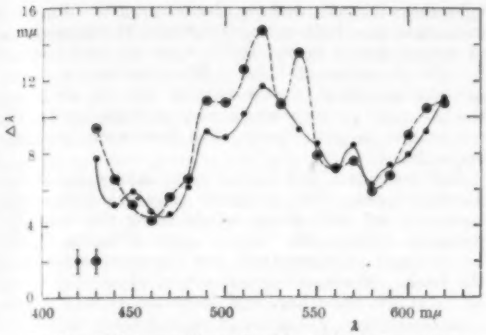
Foveal Hue Discrimination in the Presence of a White Surround

In the course of an investigation of hue discrimination in the para-central parts of the human eye[1], this property was measured also in the fovea at an intensity level of 0·95 e.f.c. The test field was bipartite, subtending an angle of 50′ at the eye, and surrounded by a white field (6°); the latter was separated from the test field by a black line. The results are shown in the accompanying figure, $\Delta\lambda$, the least perceptible difference, being plotted against λ, the short-wave limit of each step; each point represents the mean of five readings. The high-brightness data for the



○—○—, with surrounding: ●—●—, without surrounding

author's fovea are characteristic of an observer with normal colour vision and agree with Pitt and Wright's data[2]. At low brightnesses, however, there seems to be a suggestion of reduced colour vision, a finding which confirms Thomson and Trezona's results[3]. There is a subsidiary optimum at 0·53 μ which does not seem to have been reported by any other worker. While it is represented by only one point, a similar subsidiary optimum has been observed in other sets of five runs each. Its exact position seems to be very sensitive to brightness: at an intensity of 9·5 e.f.c., the two pessima at 0·52 and 0·54 μ are fused.

One way in which the optimum at 0·53 μ can be made to disappear at low brightnesses is by removing the white surround. The data for the experiment carried out in this condition are presented on the same graph; they were obtained concurrently, hence day-to-day variations should be reflected in both to the same extent. Representative samples of the respective standard errors of the mean are shown in the bottom left-hand corner. The two curves are evidently similar. Two subsidiary pessima at 0·49 μ and 0·57 μ are reproduced in both curves, and there is evidence for the belief that the latter in particular is not spurious. It will also be noticed that the familiar double bend at 0·44–0·45 μ is found only in the data obtained without the surround.

None of the existing hypotheses describing colour vision can account for these facts. Wright[2] found that preliminary low brightness-adaptation to white light effected an improvement in hue-discrimination at 0·58 μ, a deterioration with subsequent slight improvement at 0·53 μ, and a progressive deterioration at 0·494 μ. In the present case, however, the adaptation was simultaneous and outside the test field. It is difficult to escape the conclusion that the surround has improved differentiation by partly light-adapting the eye: this leads to the conclusion that linking of foveal receptor paths can take place under certain conditions. This idea has been put forward also by Lythgoe[4] largely as a result of researches on the variation of visual acuity with brightness. If visual acuity is governed by the interaction of the receptor-paths, colour vision would be expected to behave in a similar manner unless each 'visual acuity-path' represents a 'colour-unit' containing different colour mechanisms.

The interpretation of the pessimum at 0·52 μ is difficult. Although Granit[5] has found modulators occupying this spectral position in the eyes of the cat and the snake, and Hartridge[6] reports that he has found a fixation point for this wave-length, the shift of this peak in paracentral parts of the eye, on reducing the brightness, leads to the tentative suggestion that it may be due to a mixture of visual purple and indicator yellow. Dartnall[7] has given the theory of such an internal filter to account for the photopic luminosity curve and the Purkinje shift. According to his analysis, the peak of the absorption of visual purple is displaced to longer wave-lengths at higher brightnesses. While the present results do not clash with this idea, the fact that the presence and absence of a surround should produce different hue-discrimination curves makes it evident that an explanation must be given on the basis of a nervous mechanism.

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Occurrence of *Asparagopsis armata* Harv. on the Coast of Cornwall

The occurrence of *Falkenbergia* on a shore of Lundy Isle was reported last year by Harvey and Drew[1], and since then I have received specimens of this inconspicuous alga from Miss M. de Valéra collected in November 1939 from near Galway Harbour and in July 1941 at Muigh Inis, Ireland, as well as another from Miss S. M. Lodge from Lough Ine, collected in July 1949. In addition, I myself have found *Falkenbergia* cast ashore in August of this year at Falmouth and also at Kennack Sands on the Lizard Peninsula. It must be regarded, therefore, as a not uncommon component of the British marine flora. Although well developed, the Cornish plants were sterile, like all others examined.

If J. Feldmann and G. Feldmann's[2] contention that *Falkenbergia* is but a phase in the life-history of *Asparagopsis armata* Harv. is correct, then it seems likely that the latter's appearance on the English coast would follow that of *Falkenbergia*. This has indeed proved to be the case, and the frequency with which *A. armata* could be found on the shores of the Lizard Peninsula in August of this year shows that it is well established on this stretch of coast. Well-developed specimens were found at Poldhu Cove, Polurrian Cove, Kynance Cove, Coverack Cove, as well as at Kennack Sands, where they were particularly numerous on August 9, 1950, after a storm. In fact, it was the most common alga on the beach on that occasion. Attached plants were not seen; but the shores mentioned were not visited during particularly good tides. This is the first record of the occurrence of *A. armata* on the coast of England, although it has been reported on the west coast of Ireland by de Valéra[3] as having been found at Muigh Inis in July 1941. De Valéra was able to observe it growing *in situ* "on or in association with *Corallina*, on the much exposed sides of Lithothamnion-covered rocks at extreme low water mark". This alga, which

Piece of female plant of *Asparagopsis armata* Harv. collected at Coverack Cove, Cornwall on August 4, 1950 (× ½)

was described by Harvey[4] from Australia and Tasmania originally, has gradually spread in Mediterranean and Atlantic European waters and has been known for the north-west seaboard of France since 1925 [5]. Both *Falkenbergia rufolanosa* and *Asparagopsis armata* were abundant in the Bay of Concarneau and on the shores of the Isles of Glénan, in 1946. It is surprising, therefore, that it has not been found on the south-west coast of England sooner.

The Cornish plants occurred as tufts tangled round other algæ (often species of *Ulva*) and in one instance tar and feathers. From the centre of the mass, free branches, one of which is shown in the photograph, spread out. These are usually 4–6 in. in length. The photograph also shows the characteristic runner-like branches with reflexed 'barbs'. These branches, which are effective in propagating the plant vegetatively, were particularly frequent and sometimes of considerable length, the longest being about 4 in. Among the plants preserved, a number bear developing cystocarps, but no spermatangial branches have been seen.

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Diapause and Photoperiodism in the Fruit Tree Red Spider Mite (*Metatetranychus ulmi* Koch)

STUDIES by Dickson[1,2] on the oriental fruit moth (*Grapholitha molesta*) and by Way, Hopkins and Smith[3] on the tomato moth (*Diataraxia oleracea*) and other Lepidoptera have directed attention recently to the significance of light (day-length) in controlling the onset of diapause. Some earlier work on insects had already suggested that other events in the developmental cycle, such as the resumption of growth in certain tree-hole mosquitoes[4] and the appearance of sexual forms in aphids[5–7], were also determined by the duration of light. Nevertheless, a photoperiodic response of this nature, serving to adjust the life-cycle to the seasons, may perhaps be of wider occurrence in arthropods than has been generally appreciated.

The fruit tree red spider mite lays eggs of two distinct types. The 'summer' eggs are laid on the leaves of the host plant (apple being the most important), whereas the 'winter' eggs, differing slightly in size and pigmentation, are deposited mainly on the bark. 'Summer' eggs hatch in about eight days at 25° C. On the other hand, large numbers of 'winter' (diapause) eggs, collected in mid-October before the first frosts, have been kept at this temperature for as long as one year without any hatch occurring.

The egg-laying mites can be recognized as 'summer' or 'winter' females only by their eggs. But this is a useful distinction, as under uniform conditions each female lays only a single type of egg. Experiments in which mites were reared on small apple seedlings under controlled conditions have shown that both the photoperiod and temperature are implicated in the determination of the reproductive function. This is illustrated in Table 1. First-generation larvæ that had emerged from winter eggs were here used as the starting material. The numbers of winter and summer females produced in groups of ten individuals are recorded under 'w' and 's' respectively. Illumination at the leaf surface was of the order of 100 foot-candles.

Table 1

Temperature (° C.)	Photoperiod (hr. per 24 hr.)							
	8		12		16		24	
	w	s	w	s	w	s	w	s
15	10	0	9	1	0	10	0	10
25	2	8	1	9	0	10	0	10

At 15° C., winter females develop when the daily photoperiod is 8 or 12 hr.; and summer females when the photoperiod is 16 hr. or longer. Higher temperatures (for example, 25° C.) partially eliminate this photoperiod effect.

Inheritance seemingly plays no part in the determination. When subjected to the appropriate conditions, winter female gives rise to winter female in one generation, without the interpolation of summer generations; and cultures of mites maintained at 25° C. in long (16-hr.) days have to date produced twenty-five summer generations in unbroken succession.

Dierick[8] has recently reported that winter eggs in diapause can be induced to hatch by dipping them in xylol. Whatever light this observation may throw on the mechanism of diapause in the egg, there seems little doubt that in Nature cold is the responsible agency. Table 2 shows some results of exposing winter eggs, collected in October, to temperatures of

Table 2

Temperature (° C.)	% hatch after . . . days at 2–3° or 18° C.				
	50	100	150	200	300
2–3	0	7	13	68	29
18	0	0	0	0	0

2–3° and 18° C. for varying periods before returning them to 25° C. for hatching. At the lower temperature, diapause was almost completely eliminated in the surviving eggs after about two hundred days. Temperatures of 5° and 9° C. yielded very similar results, whereas no eggs hatched at 18° C.

Recent work[9,10] has shown that in England the mites pass through five generations annually. Hatching of the winter eggs usually begins in late April. There follow two generations consisting of summer females only, two of both summer and winter females and one of winter females only. The environmental agencies discussed above no doubt play a considerable part in governing the course of the life-cycle. The long obligatory period of diapause delays hatching until there is foliage available for the young mites. There is a further consequence, for the earliest developing mites of the first generation do not reach a stage sensitive to the photoperiod until mid-May, when the day-length is 15¼ hr. This timing, therefore, ensures that the first generation consists only of summer females. Winter females begin to appear in appreciable numbers in August (day-length 15¼–13¾ hr.) and become most abundant in September (day-length 12 hr. by September 25).

Further work on the physiology of diapause in red spider mites is in progress. An account will appear elsewhere.

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Factors Influencing Diapause in the European Red Mite

The European red mite, *Paratetranychus pilosus* C. and F., is a pest of considerable importance in the apple orchards of Tasmania. In the course of a detailed investigation of the problem, preliminary studies were undertaken in the 1949–50 season for the factors influencing diapause.

P. pilosus overwinters in the egg stage. The spring and early summer generations of female mites lay eggs which hatch within 5–14 days. These summer eggs, which are pale green to orange in colour, are laid on the leaves of the host plant.

In Tasmania from early February onwards successive generations contain an increasing proportion of females which lay overwintering eggs. These eggs are deep red in colour and, unlike the summer eggs, are laid almost exclusively on the wood of the tree. This change in the behaviour pattern of the females of the autumn generations was particularly noticeable in laboratory life-history studies when individual females were caged on apple leaves. Whereas in the early generations the females laid freely on the leaf surface, those of the autumn generations preferred to oviposit on either the walls or cork tops of the cages. A similar observation was made by Cagle[1], who met the needs of the females for a different oviposition site by placing small pieces of apple twig in the cages.

Cottier[2] in New Zealand suggested that the laying of winter eggs was dependent on the available food supply, commencing earlier on heavily infested trees. Although the influence of the food supply has not yet been studied in this laboratory, it is now apparent that there are other factors involved.

At a constant temperature of 68° F., 205 larvæ were bred through to the adult stage and allowed to oviposit in small cages on excised apple leaves[3] under different day-lengths produced by means of artificial lights (25-watt tungsten globes producing approximately 12 foot-candles at the leaf surface).

The percentages of females laying overwintering eggs were as follows:

Hours of light	0 hr.	6 hr.	12 hr.	18 hr.	24 hr.
% females laying overwintering eggs	92	92	100	40	12

Although these results are based on a relatively small number of females, it is apparent that the length of day had a marked influence on the development of the overwintering phase.

These tests were conducted during early autumn when a proportion of the females in the laboratory life-history studies had already commenced to lay overwintering eggs. By breeding mites under continuous light it was possible to obtain summer eggs until early winter, when apple foliage became unobtainable because of normal defoliation of the trees.

In a further limited series of tests, females that had developed and commenced to lay under one 'length of day' were transferred to different conditions. In no case was there any change in the type of egg laid—females that were laying summer eggs continued to do so, and vice versa.

It would appear, therefore, that the effect of the photoperiod was exerted on the mite during the developmental stages, and that alterations of the photoperiod in the adult stage had no effect on the type of egg laid. Whether there is any particular stage in the developmental period that is more critical has not yet been determined. Nor is it known whether the effect of the photoperiod is directly on the mite or due to the photoperiodically induced substances in the leaf being taken up by the mite in its food.

Recent work by Way *et al.*[4], on the tomato moth, *Diataraxis oleracea* L., which overwinters as a pupa; and by Dickson[5], on the oriental fruit moth, *Grapholitha molesta* (Busck), and the codling moth, *Carpocapsa pomonella* (L.), both of which overwinter as larvæ, has shown that these insects also enter diapause on a shortening day.

Detailed work on this problem is being undertaken and will be reported elsewhere.

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July 31.

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[2] Cottier, W., *N.Z. J. Sci. and Tech.*, **26**, 39 (1934).
[3] Miller, L. W., Progress Report Orchard Mite Invest. Dept. Agric. Tas. (1949).
[4] Way, M. J., Hopkins, B., and Smith, P. M., *Nature*, **164**, 615 (1949).
[5] Dickson, R. C., *Ent. Soc. Amer., Ann.*, **42**, 511 (1949).

FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

Monday, November 20

UNIVERSITY OF LONDON (in the Physiology Theatre, University College, Gower Street, London, W.C.1), at 4.45 p.m.—Dr. A. Elliott and Dr. W. E. Hanby: "Aspects of Protein Structure".* (Further Lectures on November 27, December 4 and 11.)

PASSFIELD TRUSTEES (in the William Beveridge Hall, University of London, Senate House, London, W.C.1), at 5 p.m.—Prof. W. K. Hancock: "The History of Our Time" (First Webb Memorial Lecture).*

INSTITUTION OF ELECTRICAL ENGINEERS, RADIO SECTION (at Savoy Place, Victoria Embankment, London, W.C.2), at 5.30 p.m.—Mr. J. A. V. Bates: "The Nervous System as a Communication Network".

UNIVERSITY OF LONDON (at King's College, Strand, London, W.C.2), at 5.30 p.m.—Prof. E. K. Rideal, F.R.S.: "Surface Reactions and their Significance in Biology" (Inaugural Lecture).*

ROYAL GEOGRAPHICAL SOCIETY (at 1 Kensington Gore, London, S.W.7), at 8.15 p.m.—Mr. George Salt: "An Expedition to the Shira Plateau of Kilimanjaro".

Tuesday, November 21

SOCIETY OF CHEMICAL INDUSTRY, AGRICULTURE GROUP (in the Chemistry Lecture Theatre, Royal College of Science, South Kensington, London, S.W.7), at 5 p.m.—Mr. H. Trefor Jones: "Magnesium as a Plant Nutrient".*

ROYAL INSTITUTION (at 21 Albemarle Street, London, W.1), at 5.15 p.m.—Prof. J. Monteath Robertson, F.R.S.: "Crystallography in Modern Science, (iv) Crystallography in Chemistry".

ROYAL SOCIETY OF ARTS, INDIA, PAKISTAN AND BURMA SECTION (at John Adam Street, Adelphi, London, W.C.2), at 5.15 p.m.—Prof. R. E. Mortimer Wheeler: "Archæology in India and Pakistan since 1944" (Sir George Birdwood Memorial Lecture).

SOCIETY OF CHEMICAL INDUSTRY, CHEMICAL ENGINEERING GROUP (at the Geological Society, Burlington House, Piccadilly, London, W.1), at 5.30 p.m.—Dr. R. Holroyd: "Some Aspects of Semi-Technical Scale Experimentation in Chemical Industry".

UNIVERSITY OF LONDON (in the Anatomy Theatre, University College, Gower Street, London, W.C.1), at 5.30 p.m.—Prof. H. E. M. Barlow: "Currents and Fields in Electrical Engineering" (Inaugural Lecture).*

ROYAL ANTHROPOLOGICAL INSTITUTE (in the Physiology Theatre, University College, Gower Street, London, W.C.1), at 8 p.m.—Dr. A. A. Bake: "Stick Dances and Hobby-Horses in India".

Wednesday, November 22

ROYAL SOCIETY OF ARTS (at John Adam Street, Adelphi, London, W.C.2), at 2.30 p.m.—Dr. Albert Parker: "Cities without Smoke".

ROYAL METEOROLOGICAL SOCIETY (at 49 Cromwell Road, London, S.W.7), at 5 p.m.—Mr. G. D. Robinson: "Notes on the Measurement and Estimation of Atmospheric Radiation"; Mr. H. L. Penman: "Evaporation over the British Isles".

RESEARCH DEFENCE SOCIETY (in the Physiology Lecture Theatre, University College, Gower Street, London, W.C.1), at 5.30 p.m.—Prof. E. D. Adrian, O.M., F.R.S.: "Experiments on the Nervous System" (Nineteenth Stephen Paget Memorial Lecture).

SOCIETY OF CHEMICAL INDUSTRY, MICROBIOLOGICAL PANEL OF THE FOOD GROUP (at the National Institute for Medical Research, The Ridgeway, Mill Hill, London, N.W.7), at 6.15 p.m.—Papers and demonstrations on "Recent Aids to the Study of Microbiology".

Thursday, November 23

UNIVERSITY OF LONDON (in the Anatomy Theatre, University College, Gower Street, London, W.C.1), at 1.15 p.m.—Mr. B. C. Brookes: "Criticism of the Literature of Science".*

LINNEAN SOCIETY OF LONDON (at Burlington House, Piccadilly, London, W.1), at 5 p.m.—Discussion on "What is Man?" (to be opened by Prof. A. J. E. Cave).

CHEMICAL SOCIETY, NORTH WALES SECTION (in the Department of Chemistry, University College of North Wales, Bangor), at 5.45 p.m.—Dr. F. L. Rose: "A Chemotherapeutic Search in Retrospect" (Tilden Lecture).

ROYAL AERONAUTICAL SOCIETY (at the Institution of Civil Engineers, Great George Street, London, S.W.1), at 6 p.m.—Mr. A. V. Cleaver: "Rockets and Assisted Take-off".

PLASTICS INSTITUTE, LONDON AND DISTRICT SECTION (at the Waldorf Hotel, Aldwych, London, W.C.2), at 6.30 p.m.—Mr. N. G. H. Thomas and Mr. D. G. Cavanagh: "A Survey of Polystyrene Developments".

UNIVERSITY OF LONDON (at Wye College, Wye, Ashford, Kent), at 8.15 p.m.—Dr. J. Hammond, F.R.S.: "Adaptation in Farm Animals".*

Friday, November 24

ROYAL ASTRONOMICAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 4.30 p.m.—Geophysical Discussion on "Changes in the Rotation of the Earth".

PHYSICAL SOCIETY (in the Physics Theatre, Imperial College of Science and Technology, South Kensington, London, S.W.7), at 5 p.m.—Scientific Papers.

ASLIB (at the Institution of Electrical Engineers, Savoy Place, Victoria Embankment, London, W.C.2), at 5.30 p.m.—Mr. J. B. Pears and Mr. C. W. Hanson: "Estimating the Cost and Value of Information Services".

ROYAL INSTITUTION (at 21 Albemarle Street, London, W.1), at 9 p.m.—Sir Edward Appleton, G.B.E., F.R.S.: "The Sun as a Radio Emitter".

Saturday, November 25

BRITISH PSYCHOLOGICAL SOCIETY, EDUCATION SECTION (at the Child Study Centre, Coram's Garden, 41 Brunswick Square, London, W.C.1), at 2.30 p.m.—Dr. E. A. Peel: "Testing Practical Ability".

BOTANICAL SOCIETY OF THE BRITISH ISLES (in the Lecture Hall, Royal Horticultural Society, Greycoat Street, London, S.W.1), at 3 p.m.—Exhibition Meeting.

BRITISH TRUST FOR ORNITHOLOGY in co-operation with the MANCHESTER MUSEUM (in the Chemistry Lecture Theatre, The University, Manchester), at 3 p.m.—Mr. Stuart Smith: "Aggressive Displays of some Birds"; Mr. A. G. Mason: "Experiments with Corncrakes".

Sunday, November 26

INTERNATIONAL HÆMOPHILIA SOCIETY (at 34 Eccleston Square, London, S.W.1), at 2.30 p.m.—General Meeting.*

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

LECTURER (with special responsibility) IN THE DEPARTMENT OF CHEMISTRY—The Registrar, Birmingham Central Technical College, Suffolk Street, Birmingham 1 (November 25).

PHYSICISTS (Senior Scientific Officer or Scientific Officer grade) in a Ministry of Supply Research Establishment in London, for the handling of radioactive materials—The Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting A.295/50A (November 25).

SCIENTIFIC TECHNOLOGIST I at the Coal Survey headquarters in London (duties include the recording and assimilation of Coal Survey data and the maintenance of an information service)—The National Coal Board, Establishment (Personnel), Hobart House, Grosvenor Place, London, S.W.1, quoting T7/267 (November 25).

TECHNICAL AUTHORS in various Admiralty Naval Establishments, to prepare technical publications and handbooks on electronic equipment used in H.M. ships—The Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting D.49/50A (November 25).

TECHNICAL OFFICER (woman, with a degree in chemistry and administrative or industrial experience) in the Technical and Scientific Register—The Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting F.380/50A (November 25).

ASSISTANT LECTURER IN THE DEPARTMENT OF MATHEMATICS—The Secretary, Bedford College for Women, Regent's Park, London, N.W.1 (November 27).

DIRECTOR OF ARCHÆOLOGY, Pakistan—The Office of the High Commissioner for Pakistan, 35 Lowndes Square, London, S.W.1 (November 27).

ENGINEER—The Clerk of the Lee Conservancy Catchment Board, Brettenham House, Lancaster Place, London, W.C.2, endorsed 'Engineer to the Board' (November 29).

ELECTRONIC ENGINEERS AND PHYSICISTS (Experimental Officer grade) at Ministry of Supply Research and Development Establishments in the South Midlands—The Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting D.253/50A (November 30).

ELECTRONIC ENGINEERS AND PHYSICISTS (Scientific Officer and Experimental Officer grades) at the Royal Aircraft Establishment, Farnborough, particularly in the fields of radio communications, including microwave techniques, circuit design and measurements, servo mechanisms and measurement of flight parameters—The Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting D.220/50A (November 30).

SENIOR LECTURER IN ELECTRICAL ENGINEERING—The Director, Robert Gordon's Technical College, Aberdeen (November 30).

VETERINARY RESEARCH OFFICERS in the Department of Agriculture and Lands, Southern Rhodesia—The High Commissioner for Southern Rhodesia, 429 Strand, London, W.C.2 (November 30).

AGRONOMIST IN THE DEPARTMENT OF AGRICULTURE, Gold Coast—The Director of Recruitment (Colonial Service), Sanctuary Buildings, Great Smith Street, London, S.W.1, quoting No. 27059/249.

ASSISTANT ENGINEER with Power Plant experience, to the Sudan Gezira Board—The Sudan Agent in London, Wellington House, Buckingham Gate, London, S.W.1, endorsed 'Sudan Gezira Board, Power Plant, 4/292'.

CHIEF MECHANICAL AND ELECTRICAL ENGINEER, by the Directorate General of Municipalities, Iraq—The Crown Agents for the Colonies, 4 Millbank, London, S.W.1, quoting M.N.24754(3B).

MECHANICAL ENGINEER to the Equatoria Projects Board, Nzara, Southern Sudan—The Sudan Agent in London, Wellington House, Buckingham Gate, London, S.W.1, endorsed 'Mechanical Engineer, E.P.B., 4/262'.

NUTRITION OFFICER (woman) in H.M. Colonial Service, Nigeria, to investigate and advise upon nutrition problems—The Director of Recruitment (Colonial Service), Sanctuary Buildings, Great Smith Street, London, S.W.1, quoting No. 27321/4.

PRODUCTION CHEMISTS for Royal Ordnance Factories in S.W. Scotland, S.W. England, N.W. England, Midlands and S. Wales—The Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting F.536/50A.

SENIOR RESEARCH FELLOWSHIP IN ENGLISH AGRARIAN HISTORY—The Registrar, University College, Leicester.

TEACHERS (with graduate or equivalent qualifications) OF CHEMISTRY AND PHYSICS and related subjects in the Department of Science, Sheffield College of Commerce and Technology—The Director of Education, Education Office, Sheffield 1.

UNIVERSITY LECTURER IN FAR EASTERN ART AND ARCHÆOLOGY—The Secretary of the Appointments Committee, Faculty of Oriental Languages, 56 Bateman Street, Cambridge.